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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

MICROORGANISMS OF THE SOIL[1]

SUCH statements as "the soil is not a mere sponge, but is teeming with life" or that "the earth is one of nature's vast laboratories in which microscopical wonder-workers perform incredible experiments" may have been unusual enough at one time to attract attention; but no longer is the presence or performances of these inhabitants of the soil of such novelty as to startle or dismay us. Indeed so accustomed have we become to the idea that each gram of the upper layers of the earth is filled with its millions or billions of bacteria, that the tendency is to ascribe all functions of the soil to its micro-flora and no theory is too bizarre, no miracle too improbable, so long as we may fall back upon the soil bacteria to account for it.

The apologetic statement only a short while ago of a German investigator, that perhaps, after all, the chemical condition of the soil might have almost as much to do with a given condition as the bacteria, illustrates, if nothing else, the great changes that have taken place in our conception of the constitution of the earth's surface during the last twenty years. To attempt to indicate the relative places of the various aspects of science which are concerned in problems of the soil would be as useless as it is impossible, but I might as well say at once that I do not feel that the situation calls for any particular glorification of the biologist. I do not wish to

[1] Presented at the Symposium on Soils at the Washington meeting of the American Association for the Advancement of Science.

be misunderstood as minimizing the importance of a real knowledge of the activities of the micro-flora and fauna of the earth. Rather would I hope to emphasize this aspect of the question, which I suppose is what was expected when the subject was assigned to me. It is quite as important, however, to point out the unsatisfactory state of the investigations at present and the futility of generalizing from a few known facts, acquired by disregarding a vast number of unknown, but nevertheless real, factors.

Fischer, you will remember, after a more or less critical review of the situation, came to the conclusion that we do not now possess a method of bacteriological examination of soils, which is of the least practical value. While not subscribing to this view, it must be confessed that a study of the literature on the subject indicates that much of fundamental importance remains to be done before we can hope that an investigation of the microorganisms of the soil will result in really solving some of the perplexing problems of fertility now confronting us. Even the nomenclature of the subject is so indefinite at the present time, that within the past year we have had conflicting uses of such familiar terms as "nitrification" and "nitrogen fixing" and there certainly is need for some such unification and strict definition of terms as that suggested by Lipman.

An enumeration of all the methods now in vogue for the bacteriological examination of the soil would show that the technical side of the subject is in much the same condition that water bacteriology was fifteen years ago, and until there is more uniformity in methods employed, by which comparative tests can be made, we shall not gain much from the results of the steadily increasing number of workers in this field. It is true that new points of view are occasionally presented and a distinct step in advance has been the emphasis recently placed upon the study of the organism, as far as possible, in its natural environments, rather than in artificial solutions. The work of Vogel, Stevens and others, has done something to make possible an agreement in parallel laboratory and field experiments; but, after all, progress in this line has been chiefly through pointing out the errors of others and has not resulted, as yet, in the formulation of a standard. We are much farther along in knowing what not to do, but like the Sherman law, the situation calls for some affirmative legislation.

There is also considerable evidence that we have been so obsessed by the pure culture idea, that conclusions drawn from experiments performed under such conditions are entirely unwarranted. If it is true that mixed cultures of *Azotobacter chroococcum* and *Pseudomonas radicicola* will fix almost twice as much nitrogen as either alone, to say nothing of the necessary interaction between various groups in making available green manures, phosphoric acid, lime nitrogen, etc., it is very evident that conclusions drawn from the study of a single organism can not be applied to the conditions actually existing in the soil. We might as well assume that a superior being, dipping down into our atmosphere and selecting a single individual, would be able to arrive at the various functions and activities of man on the face of the globe, by observing his behavior under such artificial conditions as it would be possible to maintain in a heavenly laboratory. It is neither necessary, nor advisable, of course, that we abandon the pure culture method. But we should recognize the limitations of our present technique and cease to generalize from such inadequate data.

Not only are standardization of methods and interpretation of results, as well as a still further recognition of the effect of various groups of bacteria, one upon the other, much to be desired; but an appreciation of the fact that something else than the bacteria go to make up the microscopical life of the soil, must be more generally taken into consideration, in our attempts to find out what actually goes on in the ground. It must be confessed that thus far any knowledge of the algal, fungal or protozoal inhabitants of the soil has tended to confuse rather than clarify any conclusions regarding the phenomena induced by a single group of organisms.

Perhaps no better example of the chaotic conditions of the present status of the microbiology of the soil can be cited than in the recent revival of a consideration of the effect of heat and various so-called antiseptics on crop production, and the supposed relations of protozoa to the problem. That the addition to soil of carbon bisulphide, toluol, ether and similar agents, will *under certain conditions* benefit *some* crops, has of course been known for nearly twenty years, and as early as 1888 Frank believed that sterilizing soil with steam increased the solubility, or availability, of mineral and organic substances.

Various theories, from the mere removal of superabundant, though harmless, bacteria, to the destruction of toxins, have been proposed to account for this beneficial effect, but it remained for Russell and Hutchinson, of the Rothamsted Station, to stimulate interest in the subject. These investigators, in October, 1909, announced that they had found the increased productiveness of partially sterilized soil to be due to an excess of ammonia, arising as a result of the bacterial decomposition of soil substances, these bacteria being able to multiply enormously on account of the removal, by heat or volatile substances, of large protozoa which normally feed upon the bacteria. This announcement was hailed both in this country and abroad as the greatest discovery pertaining to the soil, since Hellriegel's interpretation of the beneficial effect of bacteria in the root-nodules of legumes!

A student in my laboratory becoming interested in the problem, undertook a considerable number of preliminary experiments, the results of which seemed to warrant a more elaborate investigation into the effect of soil sterilization upon crop production. It is not necessary to go into details at this time, but laboratory, greenhouse and field tests all indicated most decidedly that the theory of Russell and Hutchinson is *not* of universal application, and the importance of the protozoa, so far as their effect upon bacteria is concerned, has been overestimated. It is true that Russell and Hutchinson themselves considered the removal of the protozoa as being but one factor concerned in the benefits accruing to plants, by the use of antiseptics, and it may be that the prominence given to this aspect of their work is due to the advertising propensities of those not immediately concerned with the investigations. This is unfortunately sometimes the case. The fact remains, however, that in many of the comments published by those rather closely associated with Russell and Hutchinson, the effect of antiseptics upon protozoa is deemed to be the only one worth considering, and to which all resulting benefit is due.

Within the last few months, several papers have appeared which likewise fail to agree with Russell's and Hutchinson's results. Goodey, publishing in the *Proceedings of the Royal Society*, shows that at least one important group of protozoa, micro-

photographs of which have been used most extensively to illustrate popular articles on the subjects, can have no part whatever in disposing of beneficial bacteria or influencing in any appreciable way the fertility of the soil. For it is found that the ciliated protozoa which are so characteristic a feature of cultures made from soil, exist only in the encysted stage in natural soil conditions. There remain, of course, the amœbæ and flagellates, about the condition of which in soil we are not certain as yet. But the fact that all of these organisms are able, within a short time after being removed by disinfectants, to reestablish themselves in soils, would seem to indicate that even though they might have some direct effect upon the bacterial content of the soil, the removal is so transient that the effect on crop production is negligible. This is no place for figures, but if it were I could show as the result of tests, extending over a wide field, that the number of protozoa, including flagellates, ciliates and rhizopods, existing in the soil three days after treatment with various percents of toluol, carbon bisulphide, etc., may equal or even exceed the number originally present.

Koch and Fred at the Agricultural Institute of the University of Göttingen, since the appearance of Goodey's paper, have each published independently upon the effect of ether and carbon bisulphide on lower and higher plants and conclude that for both the micro-flora of the soil and the crop it bears, the beneficial effect is purely stimulative—simply the old idea of all poisons being beneficial to growth if sufficiently dilute.

Greig-Smith, in spite of the apparent refutation of the toxin theory of Russell and Hutchinson, returns to it as affording the best explanation of the observed results. He claims to have extracted from soil a substance which is filterable through porcelain and which is toxic to bacteria. This toxin thus retards the growth of higher plants by the destruction of beneficial bacteria, but in turn is destroyed by the application of heat or volatile antiseptics. An additional effect of these agents is upon the so-called "agricere," which, according to Greig-Smith, is a mixture of saponifiable and unsaponifiable bodies, coating or waterproofing particles of soil. When heat or certain wax solvents are added to the soil, they alter the distribution of the earth wax, carrying it to the surface and causing it to segregate on the points of the soil particles. The beneficial effect of the removal of the waterproof covering is of course that the constituents of the soil are more easily attacked by the bacteria and rendered available for plant nutrition.

Bottomly, before the British Association this summer, confirmed to a certain extent the work of Greig-Smith by demonstrating the injurious effect of the "bacteriotoxines" upon the germination of seeds and their subsequent growth, the harmfulness of which could be prevented by first heating the soil.

Without further reference to contradictory results obtained by various investigators since the announcement of Russell and Hutchinson, experiments in my own laboratory indicate that the matter is probably incapable of being satisfactorily explained by any of the single factors which have been suggested. The one fact which does seem to be fairly well established is that the temporary removal from the soil of the protozoa has but little bearing on the problem. Neither is it by any means certain that the use of heat or antiseptics is universally favorable to all crops on all kinds of soil and it seems probable that the character of the soil, as well as the kind of crop, will have to be taken into considera-

tion before we can have a true explanation of why some crops are benefited by the so-called sterilization of some soils.

Aside from a very few pathogenic forms, but little is specifically known of the fungus flora of the earth. That fungi may be as abundant as the bacteria, particularly in uncultivated soils and that below the humus-containing layer, they may considerably exceed the bacteria, has been ascertained by a few analyses. But what they do and how they do it, is for the most part a matter of conjecture. To those familiar with the rapidity and certainty with which some of the higher fungi reduce organic to inorganic matter, it is evident that there is no group of organisms present in the soil that would seem to be more capable of producing profound changes in its environment. Not only do we know that a considerable amount of the decay in animal and vegetable tissue, particularly the early stages, is due to the higher fungi, but the work of Czapek and Kohn, showing that *Penicillium* and *Aspergillus* when supplied with ammonium chloride set free hydrochloric acid, as well as the demonstration of the production of an organic acid in *Penicillium* by Alsberg and Black, points to still further possibilities by plants belonging to the same, or closely related groups.

Formerly it was supposed that the number of plants whose roots entered into combination with some fungus—presumably for mutual benefit—was limited and confined to but few families. Now it is estimated that about one half of the seed plants possess within their roots some mycorhizal organism and in many notable instances the plant is unable to thrive under natural conditions without its particular fungus. Furthermore, as has been pointed out by Coville, the acidity factor in the distribution of some plants is mycological rather than purely chemical.

Our knowledge of the effect of soil fungi upon the germination of seed is also being extended. Barnard has recently shown that seed of both the common potato and *Solanum dulcamara* fail to germinate in the absence of their mycorhizal parasite, while 40–90 per cent. begin to grow in the presence of this fungus.

Whether the considerable number of wild yeast-like organisms occurring abundantly in many soils, are capable of producing profound changes in their habitat is still problematical. That certain of these may fix atmospheric nitrogen in the laboratory seems to have been demonstrated, and it appears reasonable that should conditions in the earth be favorable, we might expect yeasts to have a decided effect either upon the soil, or its inhabitants. Despite the necessity of yeasts having secondary breeding places, such as aqueous extracts from fruits and other vegetable matter, the soil must be considered the chief abode of these fungi, and not only during the colder months, but throughout the entire year.

Even less is known about the algal content of the soil than of its fungus constituents. The older literature is full of references to the nitrogen-fixing power of both grass-greens and blue-greens, but it is a striking fact that since the introduction of the pure culture method for algæ, there has been no authenticated demonstration of the power of these plants to add in the slightest degree to our store of fixed nitrogen. It is true that Heinze working with impure cultures of *Nostoc* thought he had demonstrated by a process of elimination its ability to fix nitrogen. Since *Azotobacter* was not present and the fungus in the culture could not by itself fix nitrogen, he assumed that the nitrogen accumulated must be due to the alga. But this can hardly be accepted as conclusive. While it it possible that some of the blue-greens

may have this power, it is not likely that they are of much importance and there is need of a most careful investigation of the whole subject, now fortunately under way, before we can be at all certain of what the algæ alone accomplish in the soil.

The possible beneficial relationship between the algæ and the bacteria is quite another question. I believe it is not widely known that quite independent of any surface growth of algæ, there exists in the lower layers of the soil an algal flora which in some localities, at least, is equal, bulk for bulk, to the bacterial flora. Exact quantitative estimates are difficult and in the incomplete state of the work, only approximations can be made, but it is safe to say that under some circumstances the individual algal cells, many times larger, of course, than ordinary bacteria, number between three and four million per gram of soil. For the most part these cells belong either to *Anabæna* or *Nostoc,* and without committing myself at this time to the original observations of Brand, recently confirmed by Miss Spratt, that the heterocyst of *Nostoc* and *Anabæna* gives rise to gonidia-like spores, I may say that heterocysts obtained from the deeper layers of the soil often show the contents divided in precisely the way figured by Brand and Miss Spratt. If it be true that the heterocyst is capable of giving rise to spores, it would account, of course, for the large number of isolated cells found in the soil, and further explain how there may be such an abundant algal flora below the surface, which, be it noted, is totally different, as to genera, from the surface film of algæ.

The observations relative to the fixation of atmospheric nitrogen through the association of algæ and bacteria are somewhat more satisfactory than those dealing with algæ alone. We have some experimental evidence for believing that when certain nitrogen-fixing bacteria are growing with some of the blue-green algæ, the amount of nitrogen exceeds considerably that fixed by the bacteria alone and the benefit of the combination upon growing crops is marked. Thus we have an additional complication in dealing with the vital activities of the soil, for it appears we must not only consider the interrelationships between various groups of bacteria in so-called "mixed culture," but the influence of a considerable algal flora must also be taken into account.

No discussion of the microorganisms of the soil would be complete without some reference to the nodule-forming bacteria of legumes. That the practical application of our knowledge of the effect of these, usually, but not always, beneficial bacteria must be demonstrated in the field, rather than the laboratory, goes without saying. However, it is hard to understand how we may hope to gain much definite information either as to the needs or activities of these bacteria, when conclusions regarding them are drawn exclusively from such an inconstant and uncertain source. That much depends upon the virulence of the particular strain of organism is evident and the use of nitrogen-free media, first suggested in this country and some modification of which has since been widely adopted, both at home and abroad, has resulted in increasing materially the percentage of successful inoculations. Whether the conflicting results obtained by different investigators can be harmonized, in the state of our present knowledge, is doubtful, for the conditions are bound to be so various and the bacteria themselves so sensitive to changed environment, that comparable results will seldom be obtained. Indeed, it may not be impossible that *Pseudomonas radicicola* plays a more important rôle outside of the root nodules

than within it, and instead of attempting to induce the legume organism to form nodules on other crops, we should perhaps be paying more attention to the organism as it exists in the soil, independent of the roots of any plant.[2]

In this connection, however, I may say that I now have under cultivation an organism capable of fixing nitrogen within nodules comparable in every way to those found on the legumes, but growing on a family far removed from the Leguminosæ, namely, the Aristolociaceæ.

Of the importance of the bacterial flora in rendering available, to higher plants, the various necessary mineral constituents of the soil, little need be said. That a large number of organisms are able to influence the potash, lime, magnesia, phosphorus and other minerals of the soil solution is well known. It even appears that calcium salts of various organic acids, frequently formed by plants and occurring in soils, may be oxidized to carbonates by a considerable variety of bacteria, thus conserving the lime supply to the last degree. On the other hand, it may be well to point out that the generally accepted theory regarding the action of the so-called iron-bacteria is probably incorrect. Winogradsky's hypothesis, that the soluble bicarbonate in water or soil was absorbed by the organism and, as a result of cell metabolism, changed into ferric hydroxide, was never proved, even by its author. The analogy between the appearance of iron on the walls of these forms and the oxidation processes of the sulphur and nitrate bacteria seems to have been the chief reason for its promulgation. Molisch has shown that iron is not necessary for the growth of these organisms and later other investigators proved that manganese readily replaced the iron. There seems to be no reason, therefore, for assuming that the deposition is in any way connected directly with the metabolism of the plant. Rather is the relationship similar to that existing in certain algæ and an aquatic ascomycete, recently obtained by me. Klebs showed that *Zygnema* could retain in the gelatinous layer surrounding it, not only iron, but aluminium and chromium compounds. Whether this is due to some peculiarity in the wall, or is a sort of reversed chemotaxis, with the plant attracting the metal, instead of the chemical attracting the plant, remains to be seen. Observations made on the fungus above referred to plainly indicate that it is not necessary to ascribe any respiratory or oxidizing function to the process, and if it be vital it must be something in the nature of what we might be permitted to call "vegetable magnetism."

Without going further into details, I think enough has been said to indicate the diverse character, and yet the close interrelationship, existing in the microbiological content of the soil. While it may not appear to simplify the problem, by admitting that the physiologist, the bacteriologist, the mycologist, the algologist and possibly the protozoologist, to say nothing of the chemist and physicist, must all cooperate before many fundamental problems

[2] Since writing the above, I have learned that Greig-Smith recently presented a paper before the Linnean Society of New South Wales in which he claims, by means of a special medium, to have determined the number of *Pseudomonas radicicola* per gram of cultivated soil, to be at least three millions. He, apparently from the literature on the subject, and not by actual test, assumes that the number of *Azotobacter* and similar nitrogen-fixing organisms is small and consequently concludes that the foremost place in nitrogen fixation in the soil should be given to *Pseudomonas* and not *Azotobacter*. Indeed he goes so far as to maintain that the number of *Pseudomonas* organisms in the soil affords an indication of its comparative fertility.

involving fertility and plant nutrition are finally solved, I am inclined to think this is the only means whereby we can hope for success. At least the information derived in this way is more apt to bring us to the desired state of knowledge than our present independent attitude. "The sciences gain by mutual support," wrote Pasteur. Certainly it is not by an arrogant assumption to one's self that his particular science is the "be all and end all" of human endeavor, that we shall gain any notion of what is really happening in the soil and what it all means!

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PLANT FOOD IN RELATION TO SOIL FERTILITY[1]

I take it that the only justification for me to review the subject of plant food in relation to soil fertility or crop production is the fact that recent publications from the federal Bureau of Soils have strongly affirmed that there is no necessity of applying plant food in the restoration and maintenance of soil fertility. Two principal questions are raised: First, Does plant food applied increase crop yields in harmony with recognized soil deficiencies and crop requirements? Second, Will the rotation of crops maintain the productive power of the soil by avoiding injury from possible toxic excreta from plant roots? I shall try to present facts and data and exact quotations rather than my own opinions concerning these questions of such fundamental importance in relation to systems of permanent agriculture.

In 1804 DeSaussure, the French scientist, first gave to the world a correct and almost complete statement concerning the sources of the food of plants, including not only the confirmation of Sénébier's discovery of the fixation of carbon in the formation of carbohydrates, but also the evidence of plant requirements for the essential mineral elements secured from the soil.

Sir Humphry Davy and Baron von Liebig did much to popularize this information during the following half century; and they were followed by Lawes and Gilbert, whose extensive and long-continued investigations furnished the needed proof that the soil must furnish nitrogen as well as the mineral elements; and finally, only twenty-five years ago, Hellriegel discovered the symbiotic relationship between legumes and bacteria which gives access to the inexhaustible supply of atmospheric nitrogen for soil enrichment.

Briefly, it might be said that for nearly a century the world of science has accepted and taught, and the world of advanced agricultural methods has practised, the doctrine that soil fertility maintenance and soil enrichment require the restoration or addition of plant food, including particularly phosphorus and nitrogen, which are most likely to become deficient in normal soils, potassium where needed, and sometimes lime or limestone, which always supplies calcium, and magnesium as well if dolomitic limestone be used. Of the other five essential elements, carbon and oxygen are secured from the carbon dioxid of the air, hydrogen from water, and iron from the inexhaustible supply in the soil; while the sulfur brought to the soil in rain and otherwise from the atmospheric supply, resulting from combustion and decomposition of sulfur-bearing materials, supplemented by the soil's supply and by that returned in crop residues, appears to be sufficient to meet the plant requirements and the loss by leaching.

After nearly a century of the increasing

[1] Presented at the Symposium on Soils at the Washington meeting of the American Association for the Advancement of Science.

agricultural practise of this doctrine on much of the farm land of Germany, France, Belgium, Holland, Denmark and the British Isles, those countries have approximately doubled their average acre-yields. The ten-year average yield of wheat in the United States is 14 bushels per acre, while that in Europe has gone up to 29 bushels in Germany, to 33 bushels in Great Britain, and to more than 40 bushels per acre in Denmark. The annual application of phosphorus even to the soils of Italy has already become greater than the phosphorus content of all the crops removed. The exportation of our highest grade phosphate rock from the United States to Europe now exceeds a million tons a year, carrying away from our own country twice as much phosphorus as is required for the annual wheat crops of all the states, and millions of acres of farm land in our own eastern states have already been agriculturally abandoned, because of depleted fertility and reduced productive power; so that it is now impossible for our congressmen to enter the capital of the United States from any direction without passing abandoned farms.

Ultimate analysis has shown that the most common loam soil of southern Maryland,[2] almost adjoining the District of Columbia, contains only 160 pounds of phosphorus, 1,000 pounds of calcium and about 900 pounds of nitrogen in two million pounds of surface soil, corresponding approximately to an acre of land 6⅔ inches deep. The clover crops harvested from the rich garden soil at Rothamsted in eight consecutive years removed more phosphorus and calcium from the soil than the total amounts contained in the plowed soil of this worn-out Maryland land, whose total nitrogen content is also less than would be required for seven such crops of corn as we harvest on good land in the central west, which, however, contains ten times as much of these plant foods as the depleted Maryland soil.

During the last ten years our population increased 21 per cent., the same as during the preceding decade, while the acreage of farm lands increased only 5 per cent., and the federal government reports all future possible increase in farm land at only 9 per cent. of our present acreage.

Average crop yields for four ten-year periods are now reported by the United States Department of Agriculture. A comparison of two twenty-year averages shows increased acre-yields of 1 bushel for wheat and ½ bushel for rye, while the yield of corn has decreased 1½ bushels and the yield of potatoes has decreased 7 bushels per acre, by twenty-year averages. These crops represent our greatest sources of human food, even our supply of meat being largely dependent upon the corn crop. Less than twenty-year averages are not trustworthy for a consideration of any small increase or decrease in yield per acre. It should be noted that during the last forty years vast areas of virgin wheat land have been put under cultivation, including the Dakotas, which now produce more wheat than all the states east of the Mississippi, save only Indiana and Illinois.

A comparison of the last five years with the average of the five years ending with 1900 shows that our wheat exports decreased during the decade from 198 million to 116 million bushels, and that our corn exports decreased from 193 million to 57 million bushels.

Thus we have fed our increasing population not by increasing our acre-yields, but by a slight increase in the acreage of

[2] See "Leonardtown Loam," Bureau of Soils Bulletin 54, and "Field Operations of the Bureau of Soils" in Reports for 1900 and 1901; or see pages 138 to 142 of "Soil Fertility and Permanent Agriculture," Ginn & Company, Boston.

farm land, and by a large decrease in our exportation of food stuffs; and the fact must be plain that before another decade shall have passed we shall reach the practical limit of our relief in both of these directions.

Indeed, a most common subject already discussed in the press and investigated by national, state and city authorities during the last three or four years is the high cost of plain living.

With these facts and statistics before us, let us consider the actual results secured from field and laboratory investigations:

Where wheat has been grown every year since 1844 on Broadbalk Field at Rothamsted, England, the average yield for fifty-five years has been 12.9 bushels per acre on unfertilized land, 35.5 bushels where heavy annual applications of farm manure have been made, and 37.1 bushels per acre where slightly less plant food has been applied in commercial form.

Barley grown every year on Hoos Field at Rothamsted has produced, for the same fifty-five years, an average yield of 14.8 bushels on unfertilized land, 47.7 bushels with farm manure and 43.9 bushels where much less plant food was applied in commercial form.

Potatoes grown for twenty-six consecutive years, also on Hoos Field at Rothamsted, produced, as an average, 51 bushels per acre on unfertilized land, 178 bushels where farm manure was used (reinforced with acid phosphate during the first seven years), and 203 bushels where plant food was applied in commercial form. The first year of this investigation the unfertilized land produced 144 bushels, land receiving farm manure alone produced 159 bushels and land fertilized with commercial plant food produced 328 bushels per acre.

Director A. D. Hall, of the Rothamsted Experiment Station, makes the following statement on pages 95 and 96 of his book on "The Rothamsted Experiments":

> On the plots receiving farmyard manure, and even on those receiving only a complete artificial manure, the crop was maintained in favorable seasons. No falling-off was observed which could be attributed to the land having become "sick" through the continuous growth of the same crop, or through the accumulation of disease in the soil.

In commenting upon these same experiments, Milton Whitney, Chief of the United States Bureau of Soils, makes the following statement in Farmers' Bulletin No. 257, page 14:

> One of the most interesting instances going to show that toxic substances are formed and that what is poisonous to one crop is not necessarily poisonous or injurious to another is a series of experiments of Lawes and Gilbert—the growing of potatoes for about fifteen years on the same field. At the end of this period they got the soil into a condition in which it would not grow potatoes at all. The soil was exhausted, and under the older ideas it was necessarily deficient in some plant food. It seems strange that, under our old ideas of soil fertility, if the soil became exhausted for potatoes, it should grow any other crop, because the usual analysis shows the same constituents present in all of our plants, not in the same proportion, but all are present and all necessary, so far as we know. This field was planted in barley, and on this experimental plot that had ceased to grow potatoes they got 75 bushels of barley.

If, now, we turn to the actual records of the Rothamsted experiments we find that the first crop of barley grown after twenty-six years of potatoes was 33.2 bushels per acre on unfertilized land, only 24.8 bushels where minerals alone had been used and the soil depleted of nitrogen by the potato crops, 67 bushels per acre where minerals and nitrogen had been used, and 72.4 bushels where farm manure had been applied for twenty-six years. We also find in strict harmony with Director Hall's statement, that the largest average yield of potatoes from the farm manure plots (3

and 4), either for one year or for five years, was secured after potatoes had been grown on the same land for more than fifteen years.

On permanent meadow land at Rothamsted, the average yield of hay for fifty years was 1¼ tons per acre on unfertilized land, and more than 4 tons per acre on land heavily fertilized with commercial plant food. During the last ten years of this fifty-year period the unfertilized land has produced an average yield of 1,863 pounds of hay, while the fertilized land has produced 8,490 pounds per acre.

On Barn Field at Rothamsted, mangels were grown for thirty years. The average yield per acre was 4¼ tons on unfertilized land, 19½ tons where farm manure had been applied, and 29 tons per acre where the farm manure had been reinforced with nitrogen and phosphorus in commercial form.

In 1902 the University of Illinois began a series of experiments on the common corn-belt prairie land in McLean County, on a field which had grown no wheat for thirty-two years. We first grew wheat in 1905. Four plots not receiving phosphorus produced, respectively, 28.8 bushels, 30.5 bushels, 33.2 bushels and 29.5 bushels of wheat per acre; while four other plots which differed from these only by the addition of phosphorus, at the rate of 25 pounds of that element in 200 pounds of steamed bone meal per acre per annum, produced 39.2 bushels, 50.9 bushels, 37.8 bushels and 51.9 bushels, respectively, per acre. Six years later wheat was again grown on this land, when the four plots not receiving phosphorus produced, respectively, 22.5 bushels, 25.6 bushels, 21.7 bushels and 27.3 bushels per acre, and the other four plots, which differ from these in treatment only by the phosphorus applied during the ten years, produced 57.6 bushels, 60.2 bushels, 54.0 bushels and 60.4 bushels, respectively, of wheat per acre, this being the second crop of wheat grown on this land in forty years.

This most common prairie land of the Illinois corn belt contains 600 pounds of phosphorus and 18,000 pounds of potassium per million of surface soil, while one million pounds of the subsoil contains 450 pounds of phosphorus and 27,000 pounds of potassium. This is the type of soil on which, as an average of four different tests each year under four different conditions of soil treatment, the addition of phosphorus produced an increase in yield per acre of 9.6 bushels of corn in 1902, of 17.8 bushels of corn in 1903, of 14.8 bushels of oats in 1904, of 14.4 bushels of wheat in 1905, of 1.46 tons of clover[3] in 1906, of 18.8 bushels of corn in 1907, of 17.3 bushels of corn in 1908, of 15.2 bushels of oats in 1909, of 2.56 tons of clover[3] in 1910 and an average increase of 33.8 bushels of wheat per acre in 1911.

As an average of four similar tests during the ten years, applications of potassium (costing the same as the phosphorus) increased the yield of corn by 3.1 bushels, decreased the yield of oats by 2.3 bushels, decreased the yield of clover by 70 pounds per acre and increased the yield of wheat by 0.1 bushel per acre, these being the general average results from four years of corn and from two years each of oats, clover and wheat.

If now we turn to the extensive peaty swamp soil of northern and north-central Illinois, we find by analysis that it contains in one million pounds of the surface soil 1,960 pounds of phosphorus and 2,930 pounds of potassium, or more than three times as much phosphorus and less than one sixth as much potassium as the com-

[3] Average of two tests (see Illinois Soil Report No. 2, pp. 17, 39).

mon prairie. We also find that, as an average of triplicate tests each year, potassium increased the yield of corn per acre by 20.7 bushels in 1902, by 23.5 bushels in 1903, by 29.0 bushels in 1904 and by 36.8 bushels in 1905; while the addition of phosphorus produced a decrease of 0.1 bushel in 1902 and an increase of 0.9 bushel in 1903, of 3.9 bushels[4] in 1904 and of 0.3 bushel in 1905.

As an average of the results from twenty plots of unfertilized land in the Pennsylvania rotation experiments with corn, oats, wheat and hay (clover and timothy mixed), the crop values in two consecutive twelve-year periods decreased by 26 per cent.; while, as an average of the twenty-four years, the crop values were increased 62 per cent. by farm manure and 65 per cent. with commercial plant food, as compared with the results from unfertilized land.

The records from the Agdell rotation field at Rothamsted show that as an average of the turnips, barley, clover (or beans) and wheat the yield decreased on unfertilized land by 42 per cent. measured by the results from two consecutive thirty-two-year periods; and, if we span a sixty-year period, we find that the yield of turnips on unfertilized land was 10 tons per acre in 1848 and less than ½ ton in 1908; that the barley yielded 46.5 bushels in 1849 and only 10 bushels per acre in 1909; the clover produced 2.8 tons in 1850 and less than 1 ton per acre in 1910; while the wheat following clover produced 39.7 bushels in 1851 and 24.5 bushels in 1911.

The application of plant food (for the turnip crop only) in the same rotation over a period of sixty-four years increased the average yield of turnips from 1¼ tons to 17½ tons per acre, increased the yield of the barley following from 24.4 to 38.5 bushels, then increased the average yield of legumes from 1,945 pounds to 4,413, and increased the yield of wheat after legumes from 25 to 34.8 bushels, as compared with the unfertilized land.

If, again, we span the sixty years, we find that on the fertilized land the yield of turnips was 12½ tons in 1848 and 17½ tons in 1908; that barley produced 35.9 bushels in 1849 and 33.4 bushels in 1909; that clover produced 3½ tons in 1850 and 4½ tons in 1910; while wheat yielded 30.3 bushels in 1851 and 38 bushels per acre in 1911.

Thus, the records show that during the last four years, following a sixty-year period, the plant food applied has increased the yield of wheat by 55 per cent., increased the barley by 234 per cent. and the clover by 340 per cent.; while the yield of turnips on the fertilized land was 49 times as great as on the unfertilized land.

With these facts in mind we may well consider the following statements from Whitney in Farmers' Bulletin 257:

> Apparently, these small amounts of fertilizers we add to the soil have their effect upon these toxic substances and render the soil sweet and more healthful for growing plants. We believe it is through this means that our fertilizers act rather than through the supplying of food to the plant. (Page 20.)
>
> There is another way in which the fertility of the soil can be maintained, viz., by arranging a system of rotation and growing each year a crop that is not injured by the excreta of the preceding crop; then when the time comes around for the first crop to be planted again the soil has had ample time to dispose of the sewerage resulting from the growth of the plant two or three years before. . . . Barley will follow potatoes in the Rothamsted experiments after the potatoes have grown so long that the soil will not produce potatoes. The barley grows unaffected by the excreta of the potatoes, another crop follows the barley, and the soil is then in condition to grow potatoes again.

[4] Irregular insect injury in 1904 (see Illinois Bulletin 123, pp. 251, 252).

In other experiments of Lawes and Gilbert they have maintained for fifty years a yield of about 30 bushels of wheat continuously on the same soil where a complete fertilizer has been used. They have seen their yield go down where wheat followed wheat without fertilizer for fifty years in succession from 30 bushels to 12 bushels, which is what they are now getting annually from their unfertilized wheat plot. With a rotation of crops without fertilizers they have also maintained their yield for fifty years at 30 bushels, so that the effect of rotation has in such case been identical with that of fertilization. (Pages 21, 22.)

If we turn to the Rothamsted data, we find that the first recorded yield of wheat on the unfertilized plot on Broadbalk Field was not 30 bushels, but only 15 bushels; that the average of the first eight years was 17.4 bushels; that the best fertilized plot on the same field has averaged not 30 bushels, but 37.1 bushels for fifty-five years; that, as stated above, the wheat grown in rotation, following a leguminous crop, has averaged not 30 bushels, but 25 bushels on unfertilized land, and 34.8 bushels where fertilizers are applied for turnips three years before.

The following pertinent quotations are from Whitney and Cameron in Bureau of Soils Bulletin 22:

In England and Scotland it is customary to make an allowance to tenants giving up their farms for the unused fertilizers applied in previous seasons. The basis of this is usually taken at 30 to 50 per cent. for the first year, and at 10 to 20 per cent. for the second year after application; but, in the experience of this bureau there is no such apparent continuous effect of fertilizers on the chemical constitution of the soil. (Page 59.)

It appears further that practically all soils contain sufficient plant food for good crop yield; that this supply will be indefinitely maintained. (Page 64.)

In Bureau of Soils Bulletin 55, by Whitney, entitled "Soils of the United States," issued in 1909, we find under the heading "Permanency of Soil Fertility as a National Asset" the following summarized statements:

The soil is the one indestructible, immutable asset that the nation possesses. It is the one resource that can not be exhausted; that can not be used up. (Page 66.)

From the modern conception of the nature and purpose of the soil it is evident that it can not wear out, that so far as the mineral food is concerned it will continue automatically to supply adequate quantities of the mineral plant food for crops. (Page 79.)

As a national asset the soil is safe as a means of feeding mankind for untold ages to come. (Page 80.)

As stated in the beginning, I have not planned to discuss the subject of plant food in relation to soil fertility; but I felt it a duty as well as an honor to be permitted to accept a place on your program; and I have placed before you some most important and trustworthy data bearing upon the question. I have presented some statistics for consideration in connection with the gravest problem which now confronts America; namely, the problem of restoring American soil and of maintaining American prosperity. I have quoted accurately and fairly from the teachings of Whitney and Cameron; and I also submit for your information the following quotation from Director A. D. Hall, of Rothamsted:

I can not agree with Professor Whitney's reading of the results on the Agdell field in the least. The figures he quotes for wheat are hardly justifiable as approximations, and are in spirit contrary to the general tenor of the particular experiment. . . . In my opinion the results on the Agdell rotation field are directly contrary to Professor Whitney's idea that rotation can do the work of fertilizers. (From Report of the Committee of Seven, appointed by the Association of Official Agricultural Chemists "to consider in detail the questions raised," published in full in Circular 123 of the University of Illinois Agricultural Experiment Station.)

A thousand additional proofs of the practical value and of the evident necessity of supplying plant food in systems of

permanent agriculture could easily be cited.

All long-continued investigations and, likewise, all practical agricultural experience show that great reduction in crop yields ultimately occurs unless plant food is restored to the soil; and, as a rule, the chemical composition of normal soil is an exceedingly valuable guide in determining the kinds of material which should be supplied in practical systems of soil enrichment and preservation.

Cyril G. Hopkins
University of Illinois

THE FIFTH INTERNATIONAL CONGRESS OF MATHEMATICIANS

Once every four years the mathematicians of the world meet together to discuss the new discoveries made in the various branches of their science, to review the work accomplished during the past quadrennial period, to listen to mathematical papers and to become acquainted with one another. The fifth International Congress of Mathematicians was held at Cambridge University, August 21 to 28, 1912, at the invitation of the Cambridge Philosophical Society. The four former congresses were Zurich, 1897; Paris, 1900; Heidelberg, 1904; Rome, 1908. During the World's Fair at Chicago in 1893, a similar international gathering of mathematicians was held, but this meeting is not usually included in the list of meetings of the International Congress.

The opening meeting was devoted to welcoming addresses by the president of the Cambridge Philosophical Society, Sir George Darwin, and the vice-chancellor of the university, Mr. R. F. Scott. Sir George Darwin emphasized the great trend towards specialization among modern mathematicians and referred to the great loss sustained by mathematics in the recent death of Henri Poincaré, who was probably the one man competent to appreciate mathematical research in all its diverse branches. Darwin referred to the Cambridge School of Applied Mathematicians in the last century, mentioning Airy, Adams, Maxwell, Stokes, Kelvin and Rayleigh, and analyzed the characteristic differences in the mental attitudes of the pure and applied mathematician.

The officers of the congress were elected as follows: *President,* Sir George Darwin; *Vice-presidents,* W. von Dyck, L. Fejér, R. Fujisawa, J. Hadamard, J. L. W. V. Jensen, P. A. MacMahon, G. Mitlag-Leffler, E. H. Moore, F. Rudio, P. H. Schoute, M. S. Smoluchowski, V. A. Steklov, V. Volterra; *General Secretaries,* E. W. Hobson and A. E. H. Love.

The congress was organized in four sections devoted, respectively, to arithmetic-algebra-analysis, geometry, applied mathematics and philosophical, historical and didactical questions. The section of applied mathematics was divided into two, one for mathematical physics and astronomy, the other for economics and statistics. This was done also in the case of the fourth section, one section taking up philosophy and history, the other didactics. The international committee having charge of the program appointed the first chairmen of the sections, each of whom gave a short introductory address. The other chairmen were appointed by the sections from day to day.

Section I. Arithmetic, Algebra, Analysis.—The first meeting was presided over by Professor E. B. Elliott, who in his opening address defended the British mathematician from the attacks of those who have said he is too self-centered and cared little for the furtherance of mathematical thought. In the five meetings of this section 28 papers were offered and open for discussion. Many of the papers dealt with that part of the field of analysis which centers about the integral equation. The chairmen for the meetings after the first were Professors E. Landau, E. Borel, E. H. Moore, H. von Koch.

Section II. Geometry.—The chairman of the first meeting, Dr. H. P. Baker, gave a brief survey of the present state of the theory of surfaces and extensions to space of more than three dimensions, and gave reasons for his belief that geometers were now on the threshold of many new discoveries through the

mingling of the two streams of investigations associated with the name of the French mathematician Picard and with the modern Italian school. Twenty-four papers were read. The chairmen of the later meetings were Professors F. Severi, F. Morley, J. Drach.

Section IIIa. Mathematical Physics.—Chairman Professor H. Lamb commented upon the division of applied mathematicians into three classes, those whose interests lay mainly in the pure mathematical aspect of the problems of experience, those to whom analysis was only a means towards the interpretation and coordination of phenomena, and those specially represented in the Cambridge school who found a sort of esthetic interest in the reciprocal interplay of experience and theory. Twenty-seven papers were read in this meeting and those presided over by Prince Galatzin and Professors T. Levi-Civita and P. Stäckel.

Section IIIb. Economics, Statistics and Actuarial Science.—Professor F. Y. Edgeworth, presiding at the first meeting, commented on the fact that for the first time this branch of applied mathematics had been given equal rank with the older branches and referred to the pioneering work of Marshall as a mathematical economist and to the importance of the calculus of probabilities in the development of actuarial science. Dr. M. F. Sheppard and Dr. J. F. Steffensen presided at the two last meetings. A total of 13 papers made up the program of the three meetings.

Section IVa. Philosophy and History—Four meetings of this section were held, one a joint meeting with Section IV*b*. Twenty-two papers were offered. The meetings were presided over by Hon. B. A. W. Russell, Professors A. Gutzmer, A. Padoa, F. Rudio.

Section IVb. Didactics.—The first chairman, Mr. C. Godfrey, spoke regretfully of the absence of Klein, who had done so much in promoting the work of the International Commission on the Teaching of Mathematics. The chairman happily characterized the section as devoted to the study of functions of two variables, one being mathematics, the other the student. Three of the five meetings of this section were occupied with the presentation of reports from the various countries to the International Commission. Over 150 reports have been published and 50 more are in preparation. Professors C. Bourlet, J. W. A. Young, E. Czuber, D. E. Smith, R. Fujisawa, were chairmen of the meetings at which ten papers were read. At a special meeting of this section presided over by Sir J. J. Thomson, Professor Runge read a paper on the mathematical education of the physicist which brought forth an animated discussion. Runge's report was made up from the answers received to inquiries sent to universities in many countries, which summed up that need was felt for mathematicians and physicists to draw closer together, more attention should be given to graphical and approximate methods and to numerical computation by mathematical teachers and that instruction in mathematics should be individual. Several speakers in discussing the paper deplored the widening gap between the pure mathematician and the physicist, but it was suggested that the gap should be closed not by compelling mathematical teachers to abandon logical precision, but by discarding things obsolete in the traditional mathematical courses and diminishing the excessive amount of manipulative work which is now demanded from physics students.

Besides the sectional meetings there were ten lectures given at the general meetings of the congress. These lectures were:

"Il significato della critica dei principii nello sviluppo delle matematiche," Professor F. Enriques.

"Periodicity in the solar system," Professor E. W. Brown.

"The history and evolution of arithmetic division," P. J. Harding.

"The principles of instrumental seismology," Prince B. Galitzin.

"Gelöste und ungelöste Probleme aus der Theorie der Primzahlverteilung und der Riemannschen Zetafunktion," Professor E. Landau.

"Definition et domaine d'existence des fonctions monogénes uniformes," Professor E. Borel.

"The place of mathematics in engineering practise," Sir W. H. White.

"Multiply charged atoms," Sir J. J. Thomson.

"Boundary problems in one dimension," Professor M. Bôcher.

"The dynamics of radiation," Sir J. Larmor.

The lecture by Sir W. H. White will no doubt cause a discussion with followers of Professor John Perry for the speaker preferred "pure mathematics taught by a mathematician to the so-called practical mathematics."

From a social standpoint the members were well taken care of. On Wednesday evening, August 21, they were received in the Combination Room and Hall of St. John's College by Sir George Darwin as president of the Cambridge Philosophical Society, and Mr. R. F. Scott, vice-chancellor of the university. On Friday evening they attended a reception at Fitzwilliam Museum given by Lord Rayleigh, the chancellor of the university. Sunday afternoon was given up to a reception by the committee on organization in the gardens of Christ's College. An organ recital was given in King's College chapel on Sunday night. On Monday night the master and fellows of Trinity College received the members in the college. One afternoon was devoted to an excursion to Ely and its cathedral. An excursion to Oxford was arranged for the day after the breaking up of the congress. On this day many accepted the invitation of the Marquis of Salisbury to visit Hatfield House. Facilities were given for visits to the works of the Cambridge Scientific Instrument Making Company, the visitors being entertained by Mrs. Horace Darwin. Visitors to the university observatory were entertained by Mrs. Newall. Besides these, there were many little gatherings and excursions for the ladies who did not care to attend the mathematical meetings. The feature of this congress was the hospitality of the Cambridge colleges. A majority of the members of the congress lived in the colleges and for those of us who were so fortunate, this part of the week's entertainment was one we shall long remember.

On Tuesday a procession was formed and a wreath of laurel and white flowers was carried to and placed on the grave of the Cambridge mathematician, Arthur Cayley, in Mill-road Cemetery. Professor S. Dickstein, of Warsaw, delivered an appreciation of Cayley's work. From the money left over from the subscription for the wreath a memorial of the occasion is to be made in silver and presented to the university.

The congress was well attended, the total number of members registering being 706 from 27 countries. This is somewhat larger than the attendance at Rome in 1904 and much larger than at any other congress. About 85 Americans were present. With the exception of the United Kingdom the United States was represented by the largest number of members, Germany and France coming next in order. At the last meeting the invitation of Professor Mittag-Leffler to hold the next meeting at Stockholm in 1916 was accepted. Invitations to hold the 1920 meeting in Budapesth and in Athens were received, but no action was taken.

A. R. Crathorne

THE NEW ENGLAND GEOLOGICAL EXCURSION

The twelfth annual Geological Excursion of the New England colleges and universities was held in the vicinity of Meriden, Connecticut, October 18 and 19, under the direction of Professor William North Rice, of Wesleyan University, and was attended by representatives from Amherst, Connecticut Agricultural College, Harvard, Mount Holyoke, Massachusetts Agricultural College, Massachusetts Institute of Technology, Smith, Trinity, Tufts, University of Vermont, Wesleyan, Williams, and Yale, teachers of geography from a number of the high schools of Connecticut, about fifty men and women participating.

After a collation at Fisk Hall in Middletown, given by Wesleyan University, the party listened to an illustrated lecture by Professor Barrell, of Yale University, on "Central Connecticut in the Geologic Past" and a brief statement by Professor Rice on the localities to be studied on the following day. After the meeting the party went to Meriden by trolley, where they spent the night. On Saturday morning the party went by special car on the

electric line which follows, in general, the line of the Higby Lamentation fault, stops being made to study points of geological interest. A view from a large drumlin afforded an opportunity to recognize the topography resulting from the faulting of the extensive lava sheets of the region—the anterior, main and posterior. A section in the posterior sheet was shown in which what seemed to be the vesicular surface of one flow was covered by the compact lava of a later flow. It was, however, suggested by Professor A. C. Lane that this vesicular lava may have been formed within the lava sheet as is perhaps indicated by its somewhat coarsely crystalline structure. A remarkable section near Westfield, where three faults with their drag dips are well shown, was visited (Bull. VI., Connecticut Geol. and Nat. His. Sur., Fig. 16, p. 213). From here the party walked to other points where drag dips were to be seen and visited the post-glacial Westfield gorge. On account of the rain in the afternoon only a small number ascended Lamentation Mountain. Lunch was served at the Highland Club near Meriden.

The excursion was a most interesting and instructive one, both because it was carefully planned and also because of Professor Rice's lucid explanation of the topographic effects of the great series of faults and the evidences by which the complicated structure of the region was unravelled. The unavoidable absence of Professor W. M. Davis, to whose insight we owe the first clear conception of the relations of the Connecticut traps and sand stones, was greatly regretted.

HERDMAN F. CLELAND
WILLIAMSTOWN, MASS.,
October 22, 1912

THE PAGEANT AT MOUNT HOLYOKE COLLEGE

THE festival procession of the liberal arts and sciences presented on October 8 at the seventy-fifth anniversary of Mount Holyoke College was not only a thing of brilliant beauty but to many it was also a dramatic revelation of the round of human knowledge. Planned by the faculty and presented by over six hundred students, it expressed to the audience of three thousand people in a wonderfully impressive manner the salient points in the history and ideals of the eighteen subjects represented. The procession passed for two hours through a natural amphitheater surrounded by trees glorious with unusually gay autumn foliage.

The science division was marked by boldness and effectiveness of treatment, combined with richness of coloring and fineness of detail. Heralds clad in rose and yellow were followed by the personification of "Mathematics, the golden key of the sciences." A striking group of mathematicians represented the history of mathematics from the fifteenth century B.C. to the seventeenth century A.D.

The story of man's progress toward a knowledge of heaven and earth was told by the departments of physics and astronomy. The fire-worshipers of primitive times, and a Chaldean priest studying the stars were followed by a number of the great thinkers and experimenters from Aristotle to Franklin. The material and intellectual gifts to humanity, such as the principle of the conservation of energy, the aeroplane, astronomical time, the telegraph, the steam engine, spectrum analysis, the telescope, the cathode ray, suggesting new concepts of matter, were symbolized by graceful figures suggestively costumed.

The hint of new concepts of matter was echoed in the chemistry section which dealt with the historical development of the chemical element. An aged alchemist, Boyle, Lavoisier, Priestley, Davy and Dalton ushered in a throng of dancers representing the elements. At first mingling in confused and unrelated groups in the wild strains of a Russian folk-dance they fell suddenly into harmony at the bidding of Mendelejeff clad in a Russian robe of black and scarlet. The order of the periodic system and the division of the elements into families was suggested by eight groups of four elements each, the members of each group being dressed in varying shades of one color in the following order, gray, pink, brown, green, yellow, blue, tan and lavender. Then

appeared a glittering dancing figure, radium, whose outer robe brilliant with sun-like rays was suddenly cast aside, and gray-gowned helium stood revealed.

A tri-colored banner, brown, green and yellow announced the departments of geology, botany and zoology, their motto being "Dauer im Wechsel," and their subject "Evolution in Nature." The "Sacred Goddess, Mother Earth," Flora from Botticelli's "Primavera," attended by algæ, fungi, ferns, pines and Cattleya orchids, symbolized this thought. Mendel, in monk's garb, followed, accompanied by a group of fruit flies (drosophila) with the characteristic red and white eyes, appearing in the ratio of 3:1 in the second generation.

The entire procession showed marvellous unity of thought as well as artistic blending of color and was pronounced by those who witnessed it to have a tangible educational value as well as the quality of dreamy beauty characteristic of the great pageants of the world.

SCIENTIFIC NOTES AND NEWS

Dr. Andrew D. White, the first president of Cornell University, distinguished for his work in education and diplomacy, and for his publications on history and science, celebrated his eightieth birthday on November 7.

Col. E. E. Markwick, C.B., has been elected president of the British Astronomical Association.

An international conference on time reckoning was opened at the Paris Observatory on October 15 by M. Guist'hau, minister of education; and M. Bigourdan, member of the Institute and of the Bureau des Longitudes, was elected president. The conference has been summoned mainly with the object of dealing with various practical uses of wireless telegraphy in the synchronization of time signals throughout the world.

The Council of the Institution of Civil Engineers has made the following further awards for papers read during the session 1911–12: A Watt gold medal to Professor W. H. Burr (New York), and the Crampton prize to Professor R. J. Durley (Montreal). The following Telford premiums have also been awarded for papers published in the proceedings without discussion during the same session: To Messrs. Paul Seurot (New York), David Anderson, and Harry Cunningham (London), Dr. S. P. Smith (Birmingham), Mr. E. G. Rivers (Richmond), Mr. E. H. Morris (Manchester) and Professor A. H. Gibson (Dundee). The Howard quinquennial prize for 1912 has been awarded to Mr. J. H. Darby (Sheffield), in recognition of improvements introduced by him in iron and steel production, and the Indian premium for 1912 to Mr. H. G. Mitchell (Madras).

Dr. Chester A. Reeds, for four years instructor in geology at Bryn Mawr College, has been appointed assistant curator in the department of geology and invertebrate paleontology of the American Museum of Natural History.

The government of Siam is planning to construct a public system of irrigation and drainage, and has appointed Mr. William Bradley Freeman, C.E. (Cornell, '05), of Denver, director of the project.

The *British Medical Journal* states that considerable progress has recently been made in the organization of the Australian Institute of Tropical Medicine at Townsville, Queensland. Dr. W. Nicoll, of the Lister Institute, and until recently Ernest Hart scholar of the British Medical Association, has been appointed chief assistant; Dr. Priestley, Beit Memorial scholar, an Australian graduate who for the last year has been working at the Lister Institute, has been appointed second assistant; and Dr. Young, assistant chemist at the Lister Institute, biochemist.

The University of Pennsylvania museum's yacht, *Pennsylvania,* is ready for its three-year expedition into the Amazon region. Owing to delay caused by negotiations with the Brazilian government, however, the actual start of the expedition will not be made until late in January. Mr. Algot Lange, head of the expedition, will sail for Rio de Janeiro on December 28.

THE Congo expedition of the American Museum of Natural History under the leadership of Messrs. Lang and Chapin reported from Faradje under date of August 21 that the packing of equipment and collections was well under way for the start with caravan for Avakubi and thence out of Africa by the western coast.

MR. WILFRED H. OSGOOD, of the Field Museum of Natural History, has returned from a nine-months' trip, during which he crossed the Andes of northern Peru and descended the Amazon River, studying and collecting the vertebrates of the region. Mr. Malcolm P. Anderson, who accompanied him, has remained to continue work in Peru and Brazil.

MR. J. B. TYRRELL, of Toronto, Canada, has just returned from an extended expedition into the Hudson Bay region. He went northward in the early summer by the ordinary trade route to the mouth of the Nelson River, spent the remainder of the summer on Hudson Bay, and returned from the Bay up the Severn River and by a previously unexplored route across the new district of Patricia to the line of the Grand Trunk Pacific Railway.

DR. EDWARD L. THORNDIKE, professor of educational psychology in Teachers College, Columbia University, will give a course of lectures on the Ichabod Spencer Lecture Foundation at Union College in February and March.

THE third of the present series of Harvey lectures will be delivered by Professor Joseph Erlanger, of the Washington University Medical Department, St. Louis, at the New York Academy of Medicine on the evening of November 9, at 8:30. Professor Erlanger's subject will be: "The Localization of Impulse Initiation and Conduction in the Heart."

PROFESSOR BURT G. WILDER lectured recently at Smith College on "Louis Agassiz and the Founding of the Laboratory at Penikese."

IT is stated in *Nature* that lectures on volcanic action, earth movements, the geological action of water and the evolution of scenery and life on the globe are to be delivered by Dr. Werner Marchand on October 17, 24 and 31, in the meeting rooms of the British Esperanto Association, London. They will be delivered in Esperanto.

PROFESSOR METCHNIKOFF will deliver the Lady Priestley memorial lecture for 1912 on "The Warfare against Tubercle," on November 29, in the lecture theater of the Royal Society of Medicine, London. The lecture will be given in French and illustrated by lantern pictures.

THE Chicago Academy of Sciences has announced the following course of public lectures for the fall of 1912:

October 18—"Places of Special Scientific Interest near Chicago," by Dr. Wallace W. Atwood, secretary of the academy.

October 25—"Switzerland and the Alps," by Mr. Edward Marsh McConnoughey.

November 1—"Floral Exhibits in the Academy and how to use them," by Dr. Herman S. Pepoon, of the Lake View High School.

November 8—"The Common Butterflies about Chicago," by Mr. Frank Collins Baker, curator of the Chicago Academy of Sciences.

WE learn from *Nature* that a memorial service for the late Mr. H. O. Jones, F.R.S., fellow of Clare College, Cambridge, demonstrator to the Jacksonian professor of natural experimental philosophy, and Muriel Gwendolen Jones, his wife, who were killed in the Alps in August while on their honeymoon, was held at the University Church of St. Mary the Great, Cambridge, on October 12. The service was attended by a large congregation, which included masters of several colleges, university professors and many other members of the university. The Royal Society, the Alpine Club and the Cambridge Alpine Club were also represented.

DR. ALBERT N. HUSTED, who has been connected with the New York State Normal College as student and teacher for fifty-nine years, died on October 16. He would have been seventy-nine years of age had he lived until October 19. His entire life as a teacher was spent in this institution, where he was professor of mathematics, continuing in

his work until within less than a week of his death. He was vigorous physically, possessed a charming personality and was greatly beloved by both students and faculty.

Mr. F. H. Low, the honorary secretary of the Röntgen Society, London, has died at the age of fifty-eight years.

Dr. Otto Krümmel, professor of geography at Marburg, distinguished for his work on oceanography, died on October 12, at the age of fifty-eight.

Dr. Paul Second, a distinguished Paris surgeon and professor at the University of Paris, died on October 27.

Dr. Benjamin August Freiherr Afschulten, formerly docent for chemistry at Helsingfors, died at Paris, on September 29, aged fifty-six years.

Hermann Munk, formerly professor of physiology at the veterinary college in Berlin, died in Berlin on October 1. The Berlin correspondent of the *Journal* of the American Association writes of him: "Munk was born in Posen, February 3, 1839, and studied at Göttingen and Berlin as a pupil of Johannes Müller, Hanle, Weber, Du Bois-Reymond, Virchow and Traube. In 1862 he became Privatdozent, and in 1869 professor extraordinary in Berlin. In 1876 he was called as professor ordinary of physiology to the veterinary school, and in 1880 he was appointed a regular member of the Prussian Academy of Sciences, and in 1897 regular honorary professor. After the death of Du Bois-Reymond, Munk was proposed by the Berlin faculty, in the first place, as his successor. The government refused in spite of Munk's prominence, and solely on account of his Jewish denomination, to enter into any transaction with him, a fact which, like many other similar occurrences, does not add to the fame of the Prussian government. In 1907 Munk resigned his office for reasons of health. The number of literary works produced by him is very extensive. When he was a student he delivered at Göttingen an excellent report of research on the finer structure of primitive muscular fibers. In Berlin he wrote a prize work on egg and sperm formation and fertilization of the nematodes. As assistant of Du Bois-Reymond, his studies covered chiefly the general physiology of the nerves and muscles, especially the electric phenomena. His collected pioneer works on the cerebral cortex were published in the eighties under the title 'Ueber die Funktionen der Grosshirnrinde.' His later works treat of the cardiac and laryngeal nerves, cataphonia, milk secretion and the thyroid gland. Munk was an excellent speaker and a beloved teacher, high-minded and modest."

The U. S. Civil Service Commission announce an open competitive examination for alloy chemist, for men only, to fill a vacancy in this position at a salary ranging from $2,400 to $3,000 per annum in the Bureau of Mines, Department of the Interior.

Dr. Rupert Blue, surgeon-general of the U. S. Public Health Service, is making plans to establish a museum or permanent exhibit on sanitation and hygiene. It is one of the duties of the Public Health Service to disseminate knowledge of sanitation and hygiene, and he believes that this can be greatly promoted by such a permament exhibit.

The *Observatory* states that it is proposed to establish an astronomical observatory on Grouse Mountain, British Columbia. Mr. T. S. H. Shearman, director of the Vancouver Meteorological Station, appears to be the originator of the scheme, which has the support of the British Columbia Academy of Science and astronomical and meteorological officials in Canada.

The meeting of the American Society of Naturalists at Cleveland was announced for January 1 and 2, 1913. It is expected, however, that all meetings will be held on the second.

The thirtieth annual congress of the American Ornithologists' Union will convene in Cambridge, Mass., on November 11, at 8 P.M. The evening session will be devoted to the election of officers and the transaction of other

routine business. The meetings open to the public and devoted to the reading and discussion of scientific papers will be held at the University Museum, Oxford Street, November 12–14, from 10 o'clock A.M. until 4 P.M. each day.

THE twelfth meeting of the Central Association of Science and Mathematics Teachers will be held at the Northwestern University, Evanston, on Friday and Saturday, November 29 and 30. The Great Northern Hotel, Chicago, has been selected as headquarters for out-of-Chicago members and friends. The addresses at the general sessions will be given by Professor W. C. Bagley, of the University of Illinois, and Carroll G. Pearse, superintendent of public schools, Milwaukee, Wisconsin. The programs of the five sections contain the names of many of the prominent educators of the middle west and provide for many reports and discussions of a practical nature which will prove of great interest and value to teachers of science and mathematics.

THE successful transmission of infantile paralysis in monkeys through the bite of the blood-sucking stable fly (*Stomoxys calcitrans*) has been announced by Professor M. J. Rosenau, of the Harvard Medical School, and C. T. Brues, of the Bussey Institution, Harvary University, and their results have been confirmed by Dr. J. F. Anderson, of the Public Health Service. The hypothesis advanced last year by Brues and Sheppard that the stable fly is the carrier of this disease has thus been given experimental proof, although it is still possible that other channels of infection may exist. With the exception of the investigations of Dr. Anderson, the work was done under the auspices of the Massachusetts State Board of Health.

Nature learns from Greenwich that all attempts to make observations of the recent total eclipse of the sun were frustrated by the heavy rain which prevailed in the eclipse region of Brazil on eclipse day, October 10. The Greenwich observers, Messrs. Eddington and Davidson, were located at Alfenas, an elevated village some 185 miles north of Santos, where there were also eclipse parties from France, Germany, Brazil and other countries. The Brazilian officials rendered all the assistance they could, and the government voted a sum of £5,000 for the reception of the visiting astronomers at Rio.

THE American Association for Study and Prevention of Infant Mortality at its recent Cleveland meeting adopted the following resolutions:

Resolved, That the Association for Study and Prevention of Infant Mortality recommend, in addition to birth and mortality statistics, the collection and compilation of marriage, divorce, industrial and all such social statistics as may have a relation to the problem of infant mortality.

WHEREAS, It has been shown that valuable results have been obtained from the requirement for proper inspection of dairy farms and dairy depots, before granting a permit for the production and distribution of milk, and that the score-card has been of great assistance in recording the observations made at such inspections, therefore be it

Resolved, That the efforts that are being made to secure uniform standards for inspection and uniform methods for recording the results of inspection be approved.

WHEREAS, Constructive housing legislation is made difficult by the absence of comprehensive information relating to infant morbidity and mortality to bad housing, therefore be it

Resolved, That the association emphasize the necessity of such investigation as will, if possible, reduce to a scientific basis the cost of bad housing in terms of infant morbidity and mortality.

THE second season of the Field School of Geology of the University of Chicago was spent in the San Juan Mountains of southwestern Colorado. A party of ten men went into camp near Ouray. After examining several of the mines and milling plants in that vicinity and becoming familiar with the geologic formations and structures around Ouray the party undertook a systematic geological survey of the northeast quarter of the Montrose Quadrangle. The work was extended northeastward into the Uncompahgre Quadrangle and included the study and mapping of a portion of the Black Canon of the Gunnison. The party prepared an areal geological

map of about two hundred and fifty square miles. This work was done under the direction of Dr. W. W. Atwood and in conformity as far as possible with the official methods of the United States Geological Survey.

Mr. F. H. Sterns, of the class of 1909 Oberlin College, has been employed by the Peabody Museum of Harvard University to explore an interesting class of prehistoric village sites in eastern Nebraska. A large portion of the archeological specimens collected by the exploration have been presented to the Geological Museum at Oberlin. Mr. Sterns worked in Sarpy County, Nebraska, south of Omaha. The sites evidently belong to a very early stage of Indian occupation and until Mr. Sterns's researches were either unobserved or misinterpreted. They occupied circular depressions popularly supposed to be "buffalo wallows," and thought by Professor Barbour to be the original shape of the sites. It turned out, however, that the structures were square, and that the depressions had assumed their present shape from the deposition of silt, brought in by winds and storms. The collection, which is now being unpacked in the Oberlin Geological Museum, consists of flint and jasper scrapers, knives, arrow heads and the cores from which they had been broken, besides various forms of grooved and polished axes, together with a great variety of ornaments. Some of the arrow shaft smoothers are made from pumice stone which Mr. Sterns concludes has floated down the Missouri River from Montana. The collection constitutes one of the most valuable additions in recent years to Oberlin's already large and valuable archeological material.

In the entire population of the United States illiteracy has declined from 10.7 in 1900 to 7.7 per cent. in 1910, but among children 10 to 14 years of age the decline in the 10 years was from 7.2 to 4.1 per cent. These facts appear in a statement in regard to the illiteracy of children issued by Director Durand, of the Bureau of the Census, Department of Commerce and Labor. The figures are based upon tabulations prepared by W. C. Hunt, chief statistician for population. The general decline of illiteracy marks the improvement of educational opportunities throughout the country, and this improvement is most distinctly measured in comparing the children who have just passed through the schools. Generally speaking, each successive generation in the United States shows a smaller proportion of persons unable to read and write, and this proportion is always least for the children 10 to 14 years of age. Illiteracy is therefore considerably less for children than for the aggregate population. In 1910 the whole number of children of the ages 10 to 14 years who were unable to read and write was 370,120, of whom 144,659 were white and 218,355 negroes, leaving 7,106 among Indians, Chinese and Japanese. Illiteracy among the native white children has fallen to 1.7 per cent., and among those of foreign or mixed parentage who for the most part live in cities, the proportion is as low as 0.6 per cent. On the other hand, as many as 18.9 per cent. of negro children are illiterate. In all classes of the population a marked improvement is noted in comparison with the census of 1900. Illiteracy among white children has fallen from 3.5 to 1.8 per cent., and among the negroes from 30.1 to 18.9 per cent. These figures show that illiteracy in the United States is being gradually eliminated, and that when the present generation of children grows up to manhood and womanhood illiteracy in the United States, especially among the white population, will be no greater than in the most advanced countries of Europe. This striking diminution in illiteracy among children in the last 10 years is found in all parts of the United States, and in the northern part of the country such illiteracy has almost entirely disappeared, as in this section of the country the proportion is considerably less than one per cent. of the whole number of children.

The Registrar-General in his annual summary for 1911, as summarized in the London *Times*, states that in England and Wales the marriages registered last year numbered 274,577, corresponding to a rate of 15.2 persons

married per 1,000 of the population at all ages; the number of births was 881,241, being in the proportion of 24.4 per 1,000 of the population, and the deaths numbered 527,864, or 14.6 per 1,000 of the population. The marriage rate was 0.2 per 1,000 above that in the previous year, but 0.3 below the average rate for the ten years 1901–10. The highest rate in any registration county with a population exceeding 100,000 was 17.8 in London, and the lowest rate was 11.5 in Herefordshire. A decline of 0.7 per 1,000 is recorded in the birth-rate when compared with that for 1910, which was the lowest recorded till then; and last year's rate was 2.8 per 1,000 below the average for the preceding ten years. Among the registration counties Durham had the highest birth-rate, 31.1, and Sussex, with 18.2, was at the other end of the scale. The death-rate was 1.1 per 1,000 above that in 1910, the lowest yet recorded, but was 0.8 below the average for the preceding ten years. The highest rate was 16.8 in Lancashire and the lowest was 11.4 in Middlesex. Of the deaths registered 114,798 were those of infants under one year, 263,481 those of persons between one year and 65 years of age, and 149,585 those of persons aged 65 years and upwards. Infantile mortality, measured by the proportion of deaths under one year of age to registered births, was 130 per 1,000, or 25 per 1,000 above the rate in 1910, and three above the ten years' average. In London the marriages during 1911 numbered 40,201, corresponding to a rate of 17.8 per 1,000 of the estimated population, an increase of 0.5 upon the rate in 1910 and of 0.4 upon the average rate for the five years 1906–10. After distributing the births in the chief institutions receiving maternity cases, the birth-rate in London was 24.8 per 1,000 of the population. This is the lowest rate recorded in the metropolis since civil registration was established. In 1867 the birth-rate in London attained the highest point on record, viz., 36.5 per 1,000 living; since that date the ratio has, with trifling exceptions, fallen steadily. Last year's rate of 24.8 was 0.7 below that in 1910, and no less than 2.7 below the average rate for the ten years 1901–10. The effect of the fall in the birth-rate in London is that, notwithstanding the great decline in the death-rate which has occurred since 1876–80, the natural increase of population by excess of births over deaths, which was then 13.38 per 1,000 living, has now fallen to 9.74. The death-rate in London last year was 15.0 per 1,000, or 1.3 above that in the previous year, and 0.1 above the average for the five years 1906–10. Since the beginning of this century the rate of infantile mortality in London has, with fluctuations, shown a considerable decline. It reached its lowest point, 103 per 1,000 births in 1910, and rose to 129 last year.

UNIVERSITY AND EDUCATIONAL NEWS

WORK has begun on the new graduate school at the University of Pennsylvania, which is to cost $500,000. Money for the school was willed by Colonel James M. Bennett in 1889. There will be dormitories for women as well as men.

FIFTY years after the founding of the School of Mines at Columbia University, or in September, 1914, the Schools of Engineering, its successor, will enter upon a new era and engineering will be placed on the same university plane as law and medicine. Beginning with the academic year of 1914–15 the engineering courses at the university will be composed of three years of undergraduate work, leading up to the degree of bachelor of science; and three years of postgraduate work, leading to the engineering degrees. In order to make adequate provision within the university for students who desire to prepare themselves in three years of college residence for the new courses, a program has been prepared leading to the degree of B.S. The first and practically all the second year will be offered in the present academic year of 1912–13, and the third year may be followed substantially, although modifications may be necessary to avoid conflict with the present courses for candidates for degrees under the old basis, and special programs will be arranged in case of conflict, so that students who desire to begin the new six years course may do so at

once without waiting for the full plan to go into effect in 1914.

Dr. F. P. Chillengworth, Hadam, Conn., has been appointed assistant professor of physiology in the University of Kansas.

At Princeton University the following new instructors and assistants have been appointed: James Waddell Alexander, Ray Edwin Gilman and Edward Staples Smith, instructors in mathematics; John Renshaw Carson, instructor in electrical engineering and physics; Keith Kuenzi Smith, instructor in physics; Percy Noyes Edwards, Charles Irving Place and Charles Hurlbut Sterrett, instructors in geodesy.

Dr. Hans Stille, professor of mineralogy and geology at Hamburg Technological School, has accepted a call to Leipzig, as the successor of Professor H. Credner, who has retired.

DISCUSSION AND CORRESPONDENCE

THE FIRST USE OF TRINIDAD PITCH FOR ROAD MAKING

The appearance in *The Popular Science Monthly* for July and August, 1912, of Dr. Clifford Richardson's very interesting and informing article entitled "Trinidad and Bermudez Asphalts and their Use in Highway Construction," leads me to think that the publication of the following account of what is probably the earliest American use of pitch for road making may from an historical standpoint not be devoid of interest. It was found in the course of some other research in Vol. I. of R. Montgomery Martin's "History of the West Indies, comprising Jamaica, Honduras, Trinidad, etc.," which is Vol. IV. of "The British Colonial Library" by the same author. This book was published in 1836. For its use I am indebted to the kindness of Mr. Herbert Putnam, Librarian of Congress.

On page 195, at the close of his description of La Brea, the pitch lake, is found the following footnote:

> I am indebted to the personal courtesy of Major General Sir Lewis Grant, late Governor of Trinidad, for the following facts: "The pitch of the lake has been adopted for the improvement of the roads, particularly in the fertile district of Naparima, where it was brought for the purpose from La Brea. In the wet season the roads at Naparima are almost impassable in those parts where there has been no application of the pitch; but where the pitch has been applied, which is the case for several miles in North Naparima, there is a hard surface formed, which makes transport comparatively easy, both from the support afforded and from the little friction of the hardened pitch."

From the above it may be seen that pitch was used locally for road making in Trinidad some time, possibly several years, prior to 1836, the date of Martin's book. The use of pitch in Europe, so far as the present writer has been able to ascertain, but little antedates the above. Eirinus, a Greek physician, made use in 1712 of asphalt from the Val de Travers, Neuchâtel, Switzerland, as a coating for both stone and wooden walls to protect them from decay caused by insects, changes of temperature and weather. He knew of its use in Babylon as an ingredient of mortar, and seems to have used it in the same way as a lining for cisterns and as a coating for walls and floors of warehouses. However, it seems to have been first used as a road material by Count de Sassenay, who obtained his material from the same source as Eirinus and made use of it on the roads of France as early as 1832. This seems to have been rock or block asphalt. Rock asphalt was used in paving the streets of Paris in 1838, but not on a large scale until 1854. The same material was first used on the streets of London in 1869. The first pavements of this material in the United States were laid in Newark, New Jersey, in 1870. The following year saw streets in New York paved with asphalt and shortly thereafter Philadelphia followed suit. These three cities all made use of Trinidad asphalt in the rock (*i. e.*, presumably block) form. However, its use as a paving material on a large scale in the United States began with the rehabilitation of the streets of our national capitol, Washington, in 1876–77. Here both

rock and sheet asphalt were laid, the latter so successfully that its use has become widespread throughout the world.

It is commonly believed that the Incas of Peru made use of asphalt in building roads, but no evidence has ever been found to sustain that belief, and recent travelers have seriously questioned the excellence of those roads.

That asphalt was known to the ancients is a well-attested fact, its use as a binder for masonry in Babylon being in point, but of its use other than this we know nothing. Strabo tells us that as early as 2000 B.C. the streets of Babylon were paved, and so, too, presumably were the great roads leading out from the many gates of that city. Babylon was situated in the alluvial plain of Mesopotamia and its building material was almost entirely clay, either as such or in the form of bricks. It seems rather doubtful that these latter were used to pave the streets at that early date. Asphalt was abundant and much used in building operations, and it does not seem improbable that it was utilized to improve the streets. However, this is conjecture, for none of the reference books at hand contain any record of its use as a road-making material in those far-distant times.

E. W. GUDGER

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THE "WILLIAMS' PROCESS" OF PHOTOGRAPHY

TO THE EDITOR OF SCIENCE: It may be of interest to your readers to know that as of July 1, 1912, there has been dedicated to the free use of science and scientists the patented process for photographic illustrations (U. S. Pat. No. 640,060), owned by the undersigned and known among paleontologists, who found it especially useful in specimen work, as the "Williams' Process." In brief, it consists in the deposition by sublimation on the object to be photographed of an extremely tenuous monochrome film for the purpose of obviating the reflection, refraction and distorted shadow values common in ordinary photography of certain classes of objects.

It has been a matter of great regret to the writer that a long-continued and expensive investigation, arising out of an entirely legitimate difference as to the scope and validity of the patent, has delayed until now the fulfillment of the original intention of the writer to make this dedication so soon as the expenses incurred in perfecting and establishing the patent should have been secured by the moderate royalties hitherto charged. The outcome of the controversy has entirely justified the writer's position: the opinion of the opposing experts conclusively confirming the fundamental character of the invention.

As one interested in science, the writer would have been pleased if his means had permitted the assumption of all the expenses of this patent without thought of recoupment, and is heartily sorry that there are those who felt that the failure to do so is culpable. If it is so, I can only plead that it is so in violation of no code with which I am familiar.

In view of the fact that the invention was originally made by my honored father, Dr. Henry Shaler Williams, of Cornell University, it is most desirable that certain facts be stated for the benefit of those who may in the past have been under a misapprehension as to his relation to the patent. Almost immediately after being granted the patent was transferred from him to me in good faith and in consideration of the assumption of debts incurred in its development. My father's wish always has been that the process should be made freely available to science gratis, and I promised him it should be as soon as its financial situation could be cleared up. It has never yielded a cent of profit to Henry Shaler Williams, nor was it taken over or ever handled with the idea of exploiting science or making commerce of its needs. This can not be stated too strongly. With the long-drawn-out controversy referred to my father has not only had nothing to do, but has repeatedly endeavored to induce me to abandon it.

Therefore the blame in the matter, if blame there be, is entirely mine and I cheerfully shoulder it; but he should be given complete exoneration from any such charge. Those who have been disposed to think critically of

Dr. Williams in connection with the patent have been doing a great and unwarranted injustice to a high-principled man, whose character and whose long and disinterested devotion to science should have made it unnecessary to break the silence he has long maintained, as I now do, without his knowledge, to right a wrong; and, as I sincerely hope, to remove completely any ground for misgiving on the part of any one of his many distinguished friends toward a loyal and worthy colleague.

Roger H. Williams

SCIENTIFIC BOOKS

Heredity and Eugenics. A course of lectures summarizing recent advances in knowledge in variation, heredity and evolution and its relation to plant, animal and human improvement and welfare. By William Ernest Castle, John Merle Coulter, Charles Benedict Davenport, Edward Murray East, William Lawrence Tower. The University of Chicago Press. Chicago, 1912. Pp. viii + 315. $2.50 net, $2.70 postage paid.

In view of the great leap which the study of genetics has taken in the past decade, and the notable contributions which are made almost daily, both in facts and in theories, it is hardly surprising that general systematic texts in the subject are not forthcoming at this time. Instead we have treatises of special phases of the subject, such as Mendelism or eugenics, and the publication of lectures, which are usually general summaries of more or less wide scope, attempting to keep abreast the times. Such a series of lectures delivered at the University of Chicago in the summer of 1911 is now presented to the public in book form. Considering the fact that "the lectures were given by five lecturers, with no opportunity to relate the lectures to one another other than as suggested by the assigned titles," the book, as a whole, presents a rather surprising unity, though somewhat lacking in balance and by no means covering uniformly the range of the subtitle. This, however, could not be expected under the circumstances, and the explanation in the preface disarms this criticism.

We are told that these lectures "were not intended for those trained in biology, but for a general university audience, interested in the progress of genetics as a matter of information rather than of study. The lecturers, therefore, did not address themselves to their colleagues. . . ." One familiar, however, with the "general university audience" not trained in biology, and with the difficulty the average student has in absorbing a working knowledge of such phenomena as dihybridism and multiple factors, is inclined to suspect that unless the lectures were supplemented with "asides" which are not included in the text, the "colleague," or at least the person who had made some previous study of the subject, carried more away from them than the person without preparatory biological training. It is safe to say that the comparatively small amount of repetition which occurs will prove no detriment to the general reader.

Professor Coulter undertakes the rather thankless task of paving the way for the real procession, which is to follow. In the first two chapters, dealing with "Recent Developments in Heredity and Evolution: General Introduction" and "The Physical Basis of Heredity and Evolution from the Cytological Standpoint," he has done this in an orthodox, but on the whole very clear and interesting, manner. The relation of the processes of inheritance to evolution, plant and animal breeding, and to eugenics, is pointed out and a cytological basis supplied upon which the Mendelist may hang his interpretations without compunction. Coulter, unlike many cytologists at the present time, evinces no hesitancy in placing upon the chromosomes the burden of hereditary transmission (p. 32).

In the third and fourth chapters Professor Castle treats of "The Method of Evolution" and "Heredity and Sex." These chapters are very similar to parts of the same author's recent book,[1] which is itself a series of lectures

[1] "Heredity in Relation to Evolution and Animal Breeding." D. Appleton & Co., New York, 1911.

rather than a text; but perhaps nowhere has he stated more clearly his position with respect to the methods of evolution. In this, as rather opposed to the present tendency, he stands with Darwin in his belief that the selection of small fluctuating variations has been a more potent factor in evolution than distinct genetic mutations. In other words, he believes in the changeability or modifiability of "unit-characters"—we wonder if it is with intent aforethought that he does not say "unit-factors"? From a purely logical standpoint, however, it is difficult to see why those cases which Castle adduces in support of the changeability idea—the polydactylous race of guinea pigs and the color-pattern series in rats (pp. 56–61)—are not capable of the same explanation as the size of the maize ear (pp. 54–56), in which case Castle accepts East's explanation of a number of independent factors. Castle states his position succinctly in the last paragraph of Chapter III. (p. 61), which is accordingly worth quoting in full:

"Accordingly we conclude that unit-characters are not unchangeable. They can be modified, and these modifications come about in more than a single way. Occasionally a unit-character is lost altogether or profoundly modified at a single step. This is mutation. But more frequent and more important, probably, are slight, scarcely noticeable modifications of unit-characters that afford a basis for a slow alteration of the race by selection. Mutation, then, is true, but it is a half-truth; selection is the other and equally important half of the truth of evolution, as Darwin saw it and as we see it."

Leaving aside the restricted use of "selection" in the above paragraph—for the strictest mutationist could scarcely dispense with selection as an operative force in evolution—interest centers on the question of the modifiability of unit-characters. In Chapter V., "Inheritance in the Higher Plants," Professor East takes up this point, and maintains that the instability of unit-characters does not affect "the truth of the genotype conception as a help toward an idea of the process of heredity." If Castle means by "unit-characters" the "personal qualities" of Johannsen, it would seem that East has justification in his opinion that their views are not incompatible.

One hears much criticism of Mendelists on the ground that they are too ready to think of "factors" as material things, to regard genetic formulæ as representing actualities, and to juggle with increasingly complicated theories which have no secure foundation. While it is true of all theorizing that there is danger in the joy of construction of forgetting flaws in the basic premises, this is really a criticism of individual method. Every worker should make his own reservations, however much he may try to fit his facts to this or that theory. East, who is perhaps as dyed-in-the-wool a Mendelist as there is in this country, shows commendable caution when he sums up the essentials of Mendelism in the following words (pp. 89, 90):

"Stated in fewer words, the essential feature of Mendelianism is the segregation of potential characters in the gamete in a state of apparent purity, and their recombination by the law of chance through random mating. The term 'Mendelian notation' was therefore used advisedly. Mendelian notation is a simple *interpretation* of certain *facts* of heredity *obtained in pedigree cultures.* It is a convenient notation and is used much as the element symbols are used in chemistry. *It makes no difference to analytical chemistry whether or not an atom is a reality, for the law of 'Definite and Multiple Proportions' upon which analytical chemistry is based is still valid.* In the same way it makes no difference whether one regards unit-characters as actual units and their segregation as complete, or whether one sees in organisms a mutual dependence between characters and a quantitative or partial segregation among gametic factors, the notation is useful either way to make clear the facts of heredity as shown by actual experiment."[2]

Chapter V., from which quotation has just

[2] Italics not in original.

been made, reviews the facts of Mendelism, using plant subjects as illustrations, and introduces some of the more complicated cases. In his second chapter, which considers "The Application of Biological Principles to Plant Breeding," East treats the subject in much the way he did in his earlier valuable bulletin.[3] Perhaps most interesting in the chapter is his discussion and presentation of the evidence for the stimulating effect of crossing.

By far the longest chapter is the sixth (more than a third of the whole book), by Professor Tower, on "Recent Advances and the Present State of Knowledge Concerning the Modification of the Germinal Constitution of Organisms by Experimental Processes." One feels that for general, and professedly non-technical, purposes this chapter would have been improved by the omission of much of the detail of the author's own experiments and a clear statement of the results. Certainly in its present form it does not hold the interest of the reader to an equal degree with the other chapters, and it is difficult to see how a non-biological audience can have followed the detail in the lectures. Tower sums up the evidence to prove that the "impinging of incident forces" upon the germ plasm may modify the germinal constitution of organisms, but combats "the hypothesis of the peripheral origin and transmission of variations," otherwise spoken of in common parlance as "the inheritance of acquired characters." Tower apparently does not, however, consider the fact of possible direct modification of the germinal constitution inimical to Mendelian interpretation.

Chapters VIII. and IX., by Dr. Davenport, contain much of the interesting material given in his recent book on eugenics.[4] The former, entitled "The Inheritance of Physical and Mental Traits of Man and their Application to Eugenics," is largely a catalogue of the method of inheritance of various traits in man, accompanied by family charts by way of illustration. In the second of his chapters are discussed, with concrete examples, the effects of segregation and migration and their eugenic significance, followed by the inevitable "Edwardses" and "Jukes" as examples of the descent of good and bad single lines of germ plasm.

There is little need to call attention to minor inaccuracies in a book of this nature, which really are few. The typography and proof-reading are good. On pages 124 and 125 there was noticed some confusion in referring to figures 53 and 54.

Leon J. Cole
University of Wisconsin

A Handbook of Sugar Analysis. A Practical and Descriptive Treatise for Use in Research, Technical and Control Laboratories. By C. A. Browne, Ph.D., chemist in charge of the New York Sugar Trade Laboratory. New York, John Wiley and Sons. 1912. Cloth, $6.00 net. Sugar tables separate, cloth, $1.25.

Dr. Browne's volume is the latest and certainly one of the most noteworthy publications by which the literature of the sugar-industry has been enriched within the past decade.

The author presents not only a very full selection of the most approved methods of sugar analysis, but offers—as he is most eminently qualified to do—account of the applicability and limitations of the various methods discussed.

On this account the work is of value not only to the chemist who is entrusted with the supervision and control of the laboratory of a working plant, and who, above all things, seeks to place his finger on the most accurate and practical methods of analysis, but also to the student and worker who desires to understand thoroughly the principles and theory underlying such methods.

The volume is divided into two parts. The first part is given over to a consideration of physical and chemical methods of sugar analy-

[3] "The Relation of Certain Biological Principles to Plant Breeding." By Edward M. East, Ph.D. Conn. Agr. Expt. Sta., Bull. 158, 1907.

[4] "Heredity in Relation to Eugenics." By Charles Benedict Davenport. Henry Holt & Company, New York, 1911.

sis; the second part, to the occurrence, preparation, properties and reactions of the sugars and their allied derivatives.

Part I., which covers about 500 pages, discusses the sampling of sugars and sugar products; determination of moisture; densimetric analysis; the refractometer and its applications; theory and practical application of polariscopes; the specific rotation of sugars; methods of simple and invert polarization; qualitative methods for the identification of sugars, and methods for the analysis of sugar mixtures.

Part II., in some 260 pages, deals with the formation of sugars in nature, and their classification; the mono-, di-, tri- and tetrasaccharides, the amino-sugars, cycloses and the sugar alcohols and sugar acids.

The sugar-tables, which, for convenience, are grouped together in an appendix of 100 pages, are paged independently of the rest of the volume. They may therefore be bound separately for laboratory use.

An idea of the painstaking care with which this work has been prepared may be gained from the fact that the index alone fills 69 pages. The style in which the book is written is admirably clear and concise; the merits and demerits of the various methods given are objectively and dispassionately stated; the methods endorsed by the International Commission for Uniform Methods of Sugar Analysis—of which Commission Dr. Browne is a member—receive full consideration throughout. The text is illustrated by a number of well-chosen and well-executed cuts, and the general excellence of the typography and make-up of the book reflect great credit on the publishers.

Dr. Browne is certainly entitled to the most cordial appreciation and congratulations of his fellow-workers on this classic contribution to their store of knowledge.

F. G. WIECHMANN

Popular Guide to Minerals. By L. A. GRATACAP. New York, D. Van Nostrand Company. 1912. 330 pages, 74 plates and 400 figures. Price $3.00.

This book, as its name indicates, is intended chiefly for the general reader and student. It is designed largely to assist in the study and appreciation of the mineral collections to be found in our great museums. It is to be regretted that popular interest in minerals is by no means as widespread or as active to-day as it was twenty-five years ago and it is to be hoped, therefore, that this book may help to revive the study of minerals and to restore it to its proper place as one of the more interesting and popular branches of natural science.

The book contains a section on crystallography, followed by a discussion of the physical and chemical properties of minerals. The section devoted to the description of mineral species—in harmony with the purpose of the book—has been entitled, "Guide to Collections." An extensive history of the development of mineralogy follows and the book closes with a description of the fine Bement mineral collection which belongs to the American Museum of Natural History in New York City and of which the author of the book is curator.

The illustrations comprise first a series of more than seventy plates giving photographic reproductions of some of the finer and more striking specimens in the Bement collection. Mineral specimens offer many obstacles to successful reproduction in this way and nothing but praise can be said of the results achieved. It is to be regretted that the line figures used in the book, especially in its earlier sections, have not been reproduced as successfully.

W. E. FORD

YALE UNIVERSITY

SPECIAL ARTICLES

ANTAGONISTIC ACTION OF ELECTROLYTES AND PERMEABILITY OF THE CELL MEMBRANE

1. The writer observed years ago that the newly fertilized eggs of *Fundulus* die in a 5/8 *m* NaCl solution without forming an embryo, while the addition of a very small but definite amount of a salt with a bivalent metal (with

the exception of the heavy metals) caused them to live and form an embryo.[1] Seven years ago he formulated the hypothesis that this antagonistic action of salt was primarily due to the fact that the solution of only one salt in a sufficiently high concentration alters the membrane of the cells, thereby increasing its permeability, while this increase can be inhibited through the addition of the antagonistic salt.[2] In a recent paper a summary of the facts supporting this hypothesis was given.[3] According to this hypothesis, the pure NaCl solution slowly increases the permeability of the membrane, diffuses into the egg and kills the germ, while the addition of a small amount of $MgCl_2$, $CaCl_2$, $SrCl_2$, $BaCl_2$, etc., inhibits or retards this increase of the permeability and the death of the embryo. During the last year Osterhout has published confirmatory experiments on *Laminaria*.

This summer the writer has found a new method by which it was possible to test the validity of this hypothesis for the egg of *Fundulus*. This egg has a considerably higher specific gravity than sea water. It will float in a 12/8 *m* NaCl solution but not in a 11/8 *m* NaCl solution. The method consisted in putting the eggs into solutions of a higher specific gravity than that of a 12/8 *m* NaCl solution and observing how long they will float in such a solution. For these experiments eggs were used which had been fertilized at least three or four days previously. The following striking facts were found. If the eggs are put into a 3 *m* solution of NaCl they will float, but as a rule not longer than three hours. Then they will sink to the bottom of the test tube. Before sinking they lose water as is indicated by the collapse of the membrane and the shrinking of the yolk sac. Probably some NaCl enters into the egg. When we put eggs into a 10/8 *m* solution of $CaCl_2$ they float at first, but will sink in about 1/2 hour. If we use $CaCl_2$ solutions of a still higher concentration the eggs will shrink and fall to the bottom just as fast or still faster. If, however, we put the eggs into a mixture of 50 c.c. 3 *m* NaCl + 2 c.c. 10/8 *m* $CaCl_2$ they will float three days or longer at the surface of the solution. During this time the eggs do not shrink at all or very little and the embryo keeps alive. In a mixture of 50 c.c. 2 1/2 *m* NaCl + 1 c.c. 2 1/2 *m* KCl + 0.75 c.c. 2 1/2 *m* $CaCl_2$ some of the eggs floated on the surface as long as ten days, while in a 2 1/2 *m* solution of NaCl they did not float more than a few hours. The only possible explanation of these experiments is that the membrane of the eggs of *Fundulus* is practically impermeable to water and to salts in a physiologically balanced solution. If the egg, however, is transferred to a hypertonic non-balanced solution the natural impermeability of the membrane is gradually lost and water will diffuse out of the egg and its specific gravity increase to such an extent that the egg sinks.

When the eggs are put into pure solutions of each of the following salts, $MgCl_2$, $SrCl_2$, $BaCl_2$, above a density of 1.0634 the eggs will float at first but will shrink and fall to the bottom in less than an hour; the sinking begins the more rapidly the higher the concentration. This indicates that the higher the concentration the more rapidly does the salt increase the permeability of the membrane for water. If, however, a small but definite amount of any of these salts is added to 50 c.c. 3 *m* NaCl the eggs will float on the 3 *m* NaCl solution for a considerably longer time than if no salt with a bivalent metal is added. These experiments show that the toxic or injurious action of the pure NaCl solution observed in my experiments on the *Fundulus* egg was due to an annihilation of the specific impermeability of the membrane of the egg through the action of NaCl and the subsequent entrance of this salt into the egg, and that the antagonistic action of the salts with bivalent metals was due to the fact that they inhibited the increase of permeability of the membrane for salt and water.

2. In 1899 the writer published the fact that the addition of a sufficient amount of acid causes the muscle of a frog to swell in an

[1] *Pflüger's Archiv*, 88, 68, 1901; *Am. Jour. of Physiology*, 6, 411, 1902.

[2] *Pflüger's Archiv*, 107, 252, 1905.

[3] Science, 34, 653, 1911.

$m/8$ NaCl solution; that the muscle also begins to swell after some time in a neutral hypertonic NaCl solution, while it shrinks in a sufficiently hypertonic NaCl solution if the latter is rendered acid. He ventured the suggestion that this might be a protein reaction.[4] This suggestion has since been amply corroborated by the work of Hardy, Procter and Pauli. It was, moreover, found that this antagonism between acid and salt is much stronger for the system H_2SO_4 — Na_2SO_4 than for the system HCl — NaCl.[5]

These data were utilized to find out whether the specific impermeability of the membrane of the egg of *Fundulus* is due to lipoids or to proteins. It was found that when eggs are exposed to a $N/333$ solution of acetic acid for twenty minutes, their permeability increases to such an extent, that if they are put into a mixture of 50 c.c. 3 m NaCl + 1 c.c. 2 1/2 m $CaCl_2$ they sink in less than seven hours (while the normal eggs float in such a solution for three days). If, however, the acetic acid solution is made up in $m/2$ NaCl (instead of distilled water) an exposure of the eggs of twenty minutes or more to the acid solution does not injure the membrane. Such eggs will float in 50 c.c. 3 m NaCl + 1 c.c. 2 1/2 m $CaCl_2$ three days or longer. By the same method it was ascertained that in the system H_2SO_4 — $m/2$ Na_2SO_4 the action of the acid was more effectively inhibited than in the system HCl — NaCl. From these experiments we are inclined to conclude that the increase in the permeability of the membrane for water and salt under the influence of acids is due to an alteration of the protein constituents of the membrane.

3. It was found that alcohols also increase the permeability of the membrane of the *Fundulus* egg for water (and possibly for salts). If eggs are put for sixty minutes into a grammolecular solution of methyl alcohol and then transferred to the test solution (50 c.c. 3 m NaCl + 2 c.c. 10/8 m $CaCl_2$) they will sink in less than eight hours (while the normal eggs float three days at the surface of such a solution). The relative efficiency of various alcohols for bringing about this increase in the permeability of the eggs was ascertained and it was found that each higher alcohol of the series is about three times as efficient as the preceding one. This is the well-known relation indicating effects on lipoids. The facts mentioned sub. 2 and 3 agree with the suggestion made by Natanson that cell membranes may be a mosaic of proteins and lipoids.

4. The increase in permeability caused by electrolytes and by alcohols is reversible if the eggs are put into sea water or into a $m/2$ solution of NaCl + KCl + $CaCl_2$ in the usual proportion. If the eggs are put into distilled water they may continue to live, and the fish may hatch, but the increase in permeability is not reversed. It can be shown that distilled water itself increases the permeability of the membrane very slowly.

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NEW YORK,
October 22, 1912

[4] *Pflüger's Archiv*, Bd. 75, p. 388, 1899.

[5] Beutner, *Biochemische Zeitschrift*, Bd. 39, 280, 1912.

VITAL STAINING OF CHROMOSOMES AND THE FUNCTION AND STRUCTURE OF THE NUCLEUS

ONE difficulty in studying protoplasm, particularly of living mitotic figures, is due to the slight differences in the refractive index of the various structures in the living cell. Up to the present, no satisfactory study has been made on the living chromosomes.

Our studies have been confined chiefly to the testes of the squash bug, grasshoppers and crickets, which are very favorable on account of the large size of their cells, and the clearness of the nuclear figures.

The testes were teased in Ringer's fluid and stained with Janus green (diethylsafraninazodimethylanalin) and studied in hanging drops in the Barber moist chamber. By variations in the concentration of the dye beautiful differential staining of the various cellular elements was obtained.

Masses of cytoplasmic granules varying in their position in the spermatogonia, sperma-

tocytes, spermatids and spermatozoa were stained a deep blue. The nuclear network of these cells and the chromosomes and spindle fibers, in all the division stages, were brought out with great sharpness by a somewhat longer application of the dye.

The separation of the dyad chromosomes in the metaphase figure of a primary spermatocyte of *Anasa* was observed. The transformation of anaphase figures of both spermatogonia and spermatocytes to telophase figures was easily followed.

When diethylsafraninazodimethylanalin is reduced the color changes from blue to red.

The possibility of studying nuclear reductions at once became apparent, when it was demonstrated that the stained chromosomes continued to live. By the use of appropriate methods we have been able to follow the relative rate of reduction in the nucleus and cytoplasm.

In the spermatid the first structure to turn red was found to be the "Nebenkern." Later all parts of the cell show this change. In the cells showing division figures the chromosomes and spindle fibers began to turn red while the remainder of the cell was still a deep slate blue. The same was found to be true for the nuclear network of resting cells. In the final stage of reduction, all stained cellular structures are red.

The colloidal structure of the resting and dividing nucleus was studied by means of dissections. The cells, in hanging drops, were dissected with Jena glass needles held in a three-movement pipette-holder. The needles were drawn in many cases to less than one half micron in diameter and the dissections were made under a 2 mm. Zeiss objective and Nos. 6 and 8 compensating oculars.

Resting and dividing spermatogonia, spermatocytes, spermatids and spermatozoa were dissected. Resting epithelial cells from the skin of the *Amblystoma* larva were also dissected.

The living cytoplasm of the spermatogonium, spermatocyte, spermatid and spermatozoon is extremely glutinous. It frequently adheres to the minute glass dissecting needle and a large portion of it can be drawn out into strands. This is particularly true of the spermatozoon. Dissections are greatly increased in difficulty, on account of this fact. Dying cells lose their viscidity and may be easily torn to pieces.

The masses of minute cytoplasmic granules, stained by Janus green, the "Nebenkern" and the middle piece of the spermatozoon, do not readily go into solution when dissected out in Ringer's fluid. Puncturing and tearing away parts of the cytoplasm of the spermatogonium and spermatocyte have no appreciable effect on the nucleus. When the cytoplasm or nucleus is punctured, the area immediately surrounding the needle stains a deep blue. If a portion of the nucleus be torn away the remainder does not collapse and gives no evidence whatsoever of loss of substance. The nuclear network can be torn out and is found to be a fairly concentrated, elastic gel, imbedded in a much more dilute viscous gel. Metaphase and telophase spindles neither collapse nor go into solution when freed from cytoplasm.

Single chromosomes were dissected out of cells in the prophase, metaphase and telophase stages. The chromosome is a fairly concentrated and somewhat refractive gel. It varies in elasticity in its different phases. A single metaphase chromosome was dissected out with its spindle fiber attached. The spindle fiber is a slightly refractive elastic gel and in the metaphase it seems to be continuous with the chromosome.

The nuclear network, spireme, spindle and chromosomes are imbedded in a dilute glutinous gel that is commonly invisible by the usual microscopical examination.

In two cases, while attempting to separate the daughter cells of a spermatocyte in telophase, a partial rapid reversal of the chemical and morphological changes occurring in cell-division was observed. In two seconds the daughter cells had fused and formed a single cell; the spindle fibers formed an irregular network in which the chromosomes were entangled. These observations seem to indicate that cell division is allied to contactility.

Resting epithelial cells from the skin of the *Amblystoma* larva were dissected for comparison. These cells are quite elastic. If a portion of the cytoplasm or nucleus be cut away, the remainder of the cell undergoes no demonstrable change in form. There is no evidence of a loss of substance from the nucleus when it is cut or torn. The nucleus in this cell is a quite concentrated gel. The intercellular matrix is non-viscous and highly elastic.

Extended studies in this field will be published later.

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September 25, 1912

EXPERIMENTS WITH DESICCATED THYROID, THYMUS AND SUPRARENALS[1]

THIS preliminary study of the effects of feeding the desiccated endosecretory organs was made on rabbits, guinea-pigs and fowls during June, July and August of the present year. The chief aim was to determine what proportion of the offspring of females given an excess of the dry substances were viable. The proportion of deformed offspring is not significant, but the action of the drugs on the fetuses and sucklings seems worthy of a brief note.

RESULTS IN THE PREGNANT RABBITS

Drug	Females	No. of Offspring	Deaths						Killed for Study on 4th Day
			At Birth	1 Day	2 Days	3 Days	23 Days	Living	
Thyroid..	4	24	2	10	3	6	1	2	
Thymus..	4	22	10			5		7	
Suprar...	1	11				2*		9	
Control...	1	10						6	4

From four to ten capsules (.76–1.9 gm.) of thyroid were given daily to rabbits during the last 20 days of their pregnancy, with no apparent symptoms of thyroidism. The offspring, however, either died at birth or during the first three days of lactation. Before their pregnancies it was found that from .38 gm. to .57 gm. of thyroid sufficed to produce extreme diarrhea and very rapid heart action; no exophthalmos developed. Weight decreased rapidly with .57 gm.

It was noted that if the offspring were not dead at birth and the heavy doses of thyroid were discontinued during lactation, the offspring lived.

In the case of one female of this thyroid group, preliminary feeding with thyroidectin had taken place until six days before parturition, when doses of thyroid increasing from .38 gm. to 1.52 gm. per diem were administered by the capsule method. The lactating young were killed on the third day of this treatment, although they had gained somewhat in weight during that time.

In the case of the thymus-treated females, the resistance to heavy doses (2.16–2.17 gm.) during the latter half of pregnancy also held. The offspring of three females were killed by the drug at an early age; one litter of the fourth succumbed at the third day of lactation, the other litter was born two days after the cessation of thymus feeding and though smaller than either of the two litters of the control rabbit in this series, lived. The effects of thymus on the adult females not in the later stages of pregnancy were similar to those in the non-pregnant females.

Unfortunately, but one of the suprarenal-fed rabbits gave birth during my period of experimentation. Her young were alive on the twenty-fifth day after birth, having grown much more rapidly than those of the control. Two of this litter were placed with one of the thymus females whose young had just died, on the day after birth, and two days later were dead. A third suckling from the suprarenal female was placed with the thyroid female which was receiving diminished doses during lactation, and this last adoption was successful also, but with the result that the stranger grew 5 gm. more in two days than a brother with the same initial weight in the home nest.

No discussion of these facts is needed; the table speaks for itself. These females were

[1] From the Station for Experimental Evolution, Carnegie Institution of Washington.

not pregnant during the first 31 days, when these records were kept. The certainty of this condition is known, for the animals had not brought forth young at the end of 68 days of observation.

RESULTS IN THE NON-PREGNANT RABBITS

Drug	Dose	Rabbit's Number	Effect
Thymus..	.270–1.08	III.	1.08 produced illness.
Suprar...	.54 –2.16	VI.	Steady increase in weight.
Suprar...	.54 –2.16	VIII.	Steady increase in weight.

Owing to the scarcity of guinea-pigs at the time we attempted to secure them, work was carried on with but five females. The same apparent stimulating effect of suprarenalin on the growth and well-being of the adults and young was noted in two of these females. The data of this group are not complete.

Average Dose of Drug	Effects on the Body-weights of Fowls	
	Weight at Beginning of Exp't, Kg.	Weight After 10 Days, Kg.
.355 g. thyroid....	1.574	1.35
.355 g. thyroid....	1.476	1.378
.355 g. thyroid....	1.574	1.574
.39 g. suprar.....	1.4414	1.23
.414 g. suprar.....	1.294	1.150
.39 g. suprar.....	1.180	.972
.776 g. thymus....	1.66	1.66
Control.....	1.180	1.180

The fowls exhibited no symptoms of discomfort or illness during treatment.

Eggs were secured from the fowls treated, but their paucity and the infertility of a large proportion of both the eggs of drugged hens and the control fowl render the data scarcely worth considering.

We may conclude from this study that

1. Thyroid fed in considerable quantities to pregnant female rabbits produces weakness in the offspring.

2. Thymus is similar in its effect on the offspring.

3. Suprarenalin does not hinder development in the rabbit, but appears to slightly accelerate growth.

4. Thyroid and thymus are most injurious to the suckling rabbit.

5. The fowl is not materially affected by doses of thyroid and thymus which produce diarrhea, tachycardia and alopecia in the rabbit.

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September 10, 1912

NOTICE OF NEWLY DISCOVERED EURYPTERIDS IN NEBRASKA

A bed of Eurypterids has just been discovered by the Nebraska Geological Survey in the Carboniferous shales of southeastern Nebraska, and thus a new locality is added to the list for the United States. Such localities are somewhat rare, and notice of any and every new one must be acceptable.

The Carboniferous outcrops are confined to some eight or ten counties in the extreme southeastern corner of the state, and though covered heavily by glacial clays, bold exposures occur in proximity to the bolder streams, especially the Missouri River. About a mile south of Peru, on the Missouri River front, the bluffs are limestones interbedded with thin layers of shale. But within a few hundred feet the shale thickens until the limestone pinches out altogether, and within as many feet the shale becomes increasingly arenaceous until it merges into a bed of massive cross-bedded sandstone. Within a mile this order is symmetrically reversed.

About one and a half miles south of Peru and immediately at the side of the Burlington track, and some thirty feet above the river, there occurs in this massive sandrock an irregular bed about a foot thick comprising alternating bands of sand and thin layers of compact slate-colored shale. These shale seams are seldom thicker than a quarter of an inch. They cleave readily and expose surfaces covered by innumerable leaves, stems, and their fragments. *Neuropteris* pinnules, and stems of *Calamites* are abundant.

Associated with these are the newly discovered Eurypterids. From observation in the field they seem to be adults, and yet they are diminutive, measuring but 1½ inches (38 mm.) in length. They appear to be fairly

plentiful, for seven individuals were found on a space less than one yard square. They are well preserved and, in the case of one at least, the anatomy can be worked out in detail even to the joints of the appendages.

Apparently there are three distinct forms, which probably represent as many species, and at least two genera. If study substantiates the belief that these are new, they will be described at an early date.

One is noticeably scorpioid in outline, due to a rapid constriction beginning at the ninth abdominal segment. At the sixth segment the abdomen measures 10 mm. across, while at the ninth it measures but half as much. The cephalothorax measures 5 mm. in length, the abdomen to the tip of the telson 23 mm., and the telson alone 13 mm. The segments seem to be destitute of ornamentations. Five appendages are exposed on one side and are distinct even to the individual joints, none of which are chelate, and there is no paddle.

Another form shows an abdomen expanding slightly to the fourth segment and then contracting and graduating insensibly into the pointed telson. The eyes and markings of the cephalothorax differ from the first-mentioned form. The abdominal segments are plainly ornamented by numerous and relatively large rounded prominences.

In a third form, noticeably vermiform, the slender abdomen tapers from the head shield to the telson. The cephalothorax is ornamented by two long and relatively broad genal spines which sweep backward to the telson. Ornamentation seems to be wanting on the segments. One distinct paddle is exposed. This small collection of seven Eurypterids was made under difficulties. Later in the season an unstable overhanging block of sandstone will be blasted away and at once several square yards of Eurypterid shales can be safely exposed. The expectation is that a considerable collection will be secured, which when properly studied will be figured and described in a forthcoming number of the Nebraska Geological Survey.

This set of Eurypterids belongs to the collections of Hon. Charles H. Morrill, who for so many years has been a liberal patron of geological and paleontological research in Nebraska.

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August, 1912

SOME NECESSARY CHANGES IN CEPHALOPOD NOMENCLATURE

WHILE recently engaged in unraveling the somewhat tangled synonymy of certain cephalopod mollusks, the writer has noted several usages which are thought to be contrary to accepted custom. It is the purpose of this note to bring these items to the attention of other investigators and thus perhaps avoid further confusion in the future.

The genus *Desmoteuthis* of Verrill (1881, p. 300) has long been used for a group of cranchiiform squids characterized by their elongate, transparent, weakly pigmented body, oval or elongate fins, and swollen, unstalked eyes. Although an apparently well-established genus, a careful inquiry shows the nomenclature to be very involved and necessitates a change in the prevailing terminology. Verrill's genus when first advanced was monotypic and established to contain a member of the former genus *Taonius* Steenstrup, which he identified as *T. hyperboreus* Steenstrup. According to Verrill's interpretation this would then result in the following arrangement.

Taonius Steenstrup, 1861. Type *Loligo pavo* Lesueur, 1821. Additional species *Leachia hyperborea* Steenstrup, 1856.

Desmoteuthis Verrill, Feb., 1881. Type *Taonius hyperboreus* Steenstrup. Additional species *Desmoteuthis tenera* Verrill, Dec., 1881.

So far well and good, but at the next step a complication appears, for we then find that *Desmoteuthis hyperboreus* "Steenstrup" Verrill is not the same as *Taonius hyperboreus* Steenstrup, being identical in fact (or so regarded by almost all subsequent authors) with the true *Taonius pavo*. Indeed the diagnosis originally given for *Desmoteuthis* does not fit a single one of the various species now re-

ferred to it, although it does very well for *T. pavo*. Since it would certainly appear that Verrill's own definition of his type species should have weight in this connection rather than the mistaken name which he applied to it, it follows that *Loligo pavo* Lesueur is occupying the incongruous rôle of serving as the type for two genera at the same time. The inevitable result is that *Desmoteuthis* must be regarded as absolutely synonymous with *Taonius*.

It is interesting to observe that the true *T. hyperboreus* Steenstrup appears to have been subsequently described by Verrill as *D. tenera* n. sp., so that, as indicated by the above table, his concept of *Desmoteuthis* coincides most curiously with Steenstrup's idea of *Taonius*. Thus we arrive, though through a considerably different process of reasoning at essentially the same conclusion attained by Hoyle in 1884, for some reason apparently abandoned by him since that time.

What, then, is to become of *T. hyperboreus* Steenstrup, especially since according to our modern notions that species appears in no way congeneric with *T. pavo*? Fortunately it is not necessary to add another new name to the literature, for by turning to the more lately described members of the group we learn that we may utilize the *Megalocranchia* of Pfeffer (1884, p. 24) with *M. maxima* Pfeffer as the type.

Chun (1910, pp. 302, 357) has further suggested that *Helicocranchia* Massy (1907, p. 382) may also be referable to *Desmoteuthis* (*i. e., Megalocranchia*) as a synonym, but for the present I do not think this can be taken as conclusive. The minute, separated, pedunculate fins, and more especially Miss Massy's subsequent emendation "Eyes on short stalks" (1909, p. 34), along with other characters are shared by an undescribed form obtained by the U. S. Fisheries steamer *Albatross* in the Hawaiian Islands, which certainly does not seem to be a *Megalocranchia*, but much nearer to the group *Teuthowenia* as defined by Chun.

In this connection it may be well to observe that the curious Hawaiian squid described by me in 1909 as *Helicocranchia fisheri* is certainly out of place in that genus. On the contrary it appears to be a typical *Megalocranchia* having considerable affinity with *M. maxima*. The recently described *Desmoteuthis pellucida* Chun, 1910, is also exceedingly close. A brief memorandum of the several species which seem to be referable to this genus is given below.

MEGALOCRANCHIA Pfeffer, 1884

Desmoteuthis auctt., non Verrill

Megalocranchia Pfeffer, 1884, p. 24

M. hyperborea (Steenstrup, 1856).

Leachia hyperborea Steenstrup, 1856, p. 200.

Taonius hyperboreus Steenstrup, 1861, p. 83.

Desmoteuthis tenera Verrill, 1881, p. 412, Pl. LV., Fig. 2; Pl. LVI., Fig. 3.

Taonius hyperboreus Hoyle, 1885, p. 321.

Taonius hyperboreus Hoyle, 1886, p. 191, Pl. XXXII., Fig. 12; Pl. XXXIII., Figs. 1–11.

Desmoteuthis hyperborea Pfeffer, 1908, p. 104, Fig. 119.

Desmoteuthis hyperboreus Hoyle, 1909, p. 277.

North Atlantic.

M. maxima Pfeffer, 1884.

Megalocranchia maxima Pfeffer, 1884, p. 24, Fig. 32, 32*a*.

Cape of Good Hope.

M. abyssicola (Goodrich, 1896).

Taonius abyssicola Goodrich, 1896, p. 17, Pl. V., Figs. 72–80.

Desmoteuthis abyssicola Pfeffer, 1900, pp. 191, 192.

Laccadive Sea.

M. fisheri (Berry, 1909).

Helicocranchia fisheri Berry, 1909, p. 417.

Xenoteuthis fisheri Berry, 1909, p. 419 (*error*).

Hawaiian Islands.

M. pellucida (Chun, 1910).

Desmoteuthis pellucida Chun, 1910, p. 357, Pl. LIII., Fig. 1; Pl. LIV., Figs. 1–17.

South Atlantic.

The family *Veranyidæ* has recently been founded by Chun (1910, p. 139) for the reception of that bizarre little genus, the *Octo-*

poteuthis of Rüppell (= *Verania* Krohn), which with its single species, *O. sicula* Rüppell, thus becomes the type and sole member of the new family. As on general grounds this step seems one of excellent expediency, it is not a happy task to mention that the name proposed is untenable. Krohn's *Verania* appears to have been advanced solely on the ground that *Octopodoteuthis* is a misnomer since tentacles (*i. e.*, "ten feet") are actually present except in the adult stage! At any rate *Verania* is an exact synonym of *Octopoteuthis*, and hence by the International Rules the use of its derivatives in the formation of higher groups is forbidden. The family name *Octopoteuthidæ* or perhaps *Octopodoteuthidæ*, depending upon whether we reject or accept Krohn's emendation, must therefore replace *Veranyidæ* in the sense proposed by Chun.

Similar effects of the application of the same rule are seen in the case of two other families dealt with in beautiful detail by Chun. As stated by him (1910, p. 185) the genus *Bathyteuthis* Hoyle, May, 1885 (p. 272), is apparently antedated by *Bentho-teuthis* Verrill, April, 1885 (p. 401), the annotated dates of Verrill's paper having seemingly escaped the observation of Hoyle (*cf.* 1886, p. 167; 1910, p. 408). If this be so, the family name *Bathyteuthidæ* Pfeffer (1900, pp. 152, 171) must lapse and the term *Bentho-teuthidæ* be substituted.

At the time of publishing my preliminary report on the *Albatross* Hawaiian Cephalopods, I had not seen a really characteristic description and figure of *Heteroteuthis dispar* (Rüppell) Gray, 1849. Since then I have had access to various additional publications and have come to the conclusion that my *Stephano-teuthis hawaiiensis* is quite likely congeneric with it. The latter genus should therefore be dropped as an unnecessary synonym.

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SOCIETIES AND ACADEMIES

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 462d regular meeting of the Anthropological Society of Washington, D. C., was held in the New Museum Building, Washington, on October 15, 1912.

Major Sylvester, superintendent of police for the District of Columbia, read a very interesting practical paper concerning criminal characteristics. It began with a brief review of the history of crime and the succession of different kinds of crimes prevalent at different periods, beginning with the cruder, such as homicide and tending toward the subtler, so that quite recently the green goods man has become less conspicuous than the forger and embezzler. The general government, it continued, has been urged to establish a national bureau of criminal identification, but such cooperative work has been left to the heads of American police departments.

It pointed out the practical difficulties of establishing a standard of the normal human being, and the imperfection of our distinction of criminals therefrom, since the police tests are applied only to those who have broken the law and many are non-criminal simply from lack of occasion. Also, we are learning that many cases of apparent criminality are only cases of mental defect or disease.

The popular impression of the criminal as a hungry, shifty individual is erroneous. The average man who makes crime a business in large cities is a fairly prosperous individual, with no fear of arrest. Some of the anatomical characteristics which Lombroso thought decisive of criminality are common in the lower races of man, whether criminal or not. Measurements in general would give racial characteristics rather than criminal.

A number of criminals charged with murder were compared in detail, with the result of showing many varieties of human appearance bracketed together.

Some special kinds of crime call for peculiarities of appearance and develop them, but with these exceptions the criminal does not usually have a different aspect from that of other people, though both criminal and non-criminal of the police classification differ among themselves. Stress was laid on conditions as largely determining the category to which a man would belong.

The paper was discussed by Drs. Hrdlička, Frank Baker, Hough, Glueck and others. The former two gentlemen chiefly emphasized the unreliability of external peculiarities relied on by Lombroso and of every sort of test which has been devised for general distinctions. Dr. Hrdlička insisted that crime is a matter of the nerves and brain or the mentality and criminal characteristics may be more due to organs and parts which are hidden than to the obvious and chiefly irrelevant external ones which Lombroso depended upon for his diagnosis. Dr. Hough chiefly explained tattooing as devoid of significance in primitive conditions, but in civilization a survival ordinarily indicating some weakness which might predispose to crime. Dr. Glueck stated his practical experience in charge of the criminal branch of the Government Hospital for the Insane and the necessity which was felt of learning all about a man's past and conditions and his behavior at every stage of his life rather than trusting to his behavior or condition at the time of any one act as a proof of criminality.

Major Sylvester condemned the evil influence of politics in preventing the police of some large cities from bringing criminals to justice.